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CONTRIBUTIONS TO THE BRYOLOGICAL FLORA OF THE PHILIPPINES, V

By V. F. BROTHERUS
(Helsingfors, Finland)

The first manuscript of this paper was lost through the sinking of the steamer that carried it. As I unfortunately had retained no copy of it, I was obliged to rewrite the entire paper, which explains the delay in the preparation and publication of it.

In the present paper the geographic distribution is not indicated for those species which were included in the former parts.[1]

DICRANACEAE

TREMATODON Michaux

TREMATODON PAUCIFOLIUS C. Müll.

LUZON, Batangas Province, Taal Volcano, on bluffs near the lake, altitude 4 meters, *Merrill 10610.*

TREMATODON DREPANELLUS Besch.

LUZON, Benguet Subprovince, Baguio and vicinity, *Merrill 7869, 7879, 14051:* Ifugao Subprovince, *Bur. Sci. 20048, 20047 McGregor.*

TREMATODON CAPILLIPES C. Müll.

LUZON, Cagayan Province, Abulug River, *Weber 1588.*
Area: Philippines.

CAMPYLOPODIUM (C. Müll.) Bescherelle

CAMPYLOPODIUM EUPHOROCLADUM (C. Müll.) Besch.

LUZON, Abra Province, Mount Posuey, *Bur. Sci. 27094 Ramos.*

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[1] Brotherus, V. F., Contributions to the Bryological flora of the Philippines, I, *Öfversigt Finska Vetensk.-Soc. Förhandl.* 47 [11] (1905) 1–12; II, *Philip. Journ. Sci.* 3 (1908) *Bot.* 11–30; III, *op. cit.* 5 (1910) *Bot.* 137–162; IV, *op. cit.* 8 (1913) *Bot.* 65–98.

DICRANOLOMA Renault

DICRANOLOMA MONOCARPUM Broth. sp. nov.

Dioicum; robustulum, caespitosum, caespitibus laxis, lutescenti-viridibus, nitidis; *caulis* usque ad 7 cm longus, adscendens vel erectus, ubique ferrugineo-tomentosus, densiuscule foliosus, simplex; *folia* patula, comalia plerumque subsecunda, canaliculato-concava, haud plicata, e basi ovata sensim lanceolato-subulata, usque ad 8 mm longa et c. 0.6 mm lata, ultra medium anguste limbata, superne dense et argute serrata, nervo tenui superne dorso argute serrato, cellulis elongatis, incrassatis, lumine angustissimo, alaribus numerosis, fusco-aureis; *seta* solitaria, usque ad 2 cm alta, tenuissima, straminea; *theca* indistincte strumifera, anguste cylindrica, arcuatula, fusca. Caetera ignota.

LUZON, Camarines Province, Mount Isarog, *Bur. Sci. 22114 Ramos.*

Species *D. assimili* (Hamp.) Par. affinis, sed foliis angustioribus sporogoniisque solitariis dignoscenda.

DICRANOLOMA TENUIRETE Broth. sp. nov.

Dioicum; gracilescens, caespitosum, caespitibus densis, pallide lutescenti-viridibus, nitidis; *caulis* usque ad 4 cm longus, adscendens, ubique ferrugineo-tomentosus, dense foliosus, simplex vel furcatus; *folia* falcata, canaliculato-concava, sicca plicatula, e basi ovata sensim lanceolato-subulata, usque ad 7 mm longa et c. 0.75 mm lata, ultra medium anguste limbata, superne argute serrata, nervo tenui, superne dorso argute serrato, cellulis breviter linearibus, haud incrassatis, alaribus numerosis, fusco-aureis. Caetera ignota.

LUZON, Abra Province, Mount Posuey, *Bur. Sci. 27090 Ramos.*

Species e minoribus, cum *D. ramosii* Broth. comparanda, sed foliis falcatis nec non cellulis haud incrassatis dignoscenda.

CAMPYLOPUS Bridel

CAMPYLOPUS ERICOIDES (Griff.) Jaeg.

LUZON, Laguna Province, Mount Maquiling, *Bur. Sci. 17075 Robinson.*
Area: Nepal, Khasia, Ceylon, Luzon.

CAMPYLOPUS HEMITRIUS (C. Müll.) Jaeg.

LUZON, Laguna Province, Mount Banahao, *Bur. Sci. 9889 Robinson.*
Area: Luzon.

CAMPYLOPUS ERICOIDES (Griff.) Jaeg.

LUZON, Laguna Province, Mount Maquiling, *Bur Sci. 17075 Robinson.*
Area: India and Luzon.

PILOPOGON Bridel

PILOPOGON BLUMEI (Doz. et Molk.) Broth.

LUZON, Lepanto Subprovince, Malaya Mountains, *Bona 147;* Camiguin de Mindanao, *Bur. Sci. 14898 Ramos.*

PILOPOGON SUBEXASPERATUS (C. Müll.) Broth.

LUZON, Bontoc Subpropince, *Vanoverbergh 1809:* Ifugao Subprovince, Mount Polis, *Bur. Sci. 20315 McGregor:* Nueva Vizcaya Province, *Bur. Sci. 20220 McGregor.*

LEUCOBRYACEAE

LEUCOBRYUM Hampe

LEUCOBRYUM SANCTUM Hamp.

LUZON, Laguna Province, San Antonio, *Bur. Sci. 20620, 20626 Ramos;* Mount Maquiling, *Bur. Sci. 20856 Villamil;* Paete, *Bur. Sci. 10059 Ramos:* SAMAR, *Bur. Sci. 17621 Ramos.*

LEUCOBRYUM SCALARE C. Müll.

LUZON, Laguna Province, *Bur. Sci. 23277 McGregor;* Mount Maquiling, *Baker 2590.*

Area: Singapore, Java, Sumbawa and Luzon.

Var. **TJIBODENSIS** Fleisch.

CAMIGUIN DE MINDANAO, *Bur. Sci. 14887 Ramos* (f. *robusta*). PALAWAN Mount Capoas, *Merrill 9096* (f. *robusta*).

Area: Java.

LEUCOBRYUM BOWRINGII Mitt.

LUZON, Laguna Province, Mount Maquiling, on trees, altitude 750 meters, *Bur. Sci. 17055 Robinson.*

LEUCOBRYUM SERICEUM Broth.

LUZON, Tayabas Province, Guinayangan, *Bur. Sci. 20920 Escritor.*

OCTOBLEPHARUM Hedwig

OCTOBLEPHARUM ALBIDUM (L.) Hedw.

LUZON, Nueva Vizcaya Province, *Bur. Sci. 20221 McGregor.* PANAY, Iloilo Province, Larena, on dead trees, alt. 750 meters, *Bur. Sci. 18220 Robinson.*

SCHISTOMITRIUM Dozy et Molkenboer

SCHISTOMITRIUM APICULATUM Doz. et Molk.

LUZON, Pangasinan Province, Umingan, *Bur. Sci. 18356 Otanes.* MINDANAO, Zamboanga Province, *Merrill 8362.*

SCHISTOMITRIUM COPELANDII Broth.

BASILAN, *Bur. Sci. 16269 Reillo.*

SCHISTOMITRIUM ROBUSTUM Doz. et Molk.

BASILAN, *Bur. Sci. 16271 Reillo.*

LEUCOPHANES Bridel

LEUCOPHANES CANDIDUM (Hornsch.) Lindb.

LUZON, Rizal Province, *Bur. Sci. 19316 Reillo:* Sorsogon Province, *Bur. Sci. 23745 Ramos.* SAMAR, *Bur. Sci. 17622 Ramos.* BASILAN, *Bur. Sci. 16274 Reillo.*

FISSIDENTACEAE

FISSIDENS Hedwig

FISSIDENS BRAUNII (C. Müll.) Doz. et Molk.

LUZON, Laguna Province, Mount Maquiling, *Bur. Sci. 17013 Robinson.*

Area: Java and Luzon.

FISSIDENS (AMBLYOTHALLIA) ROBINSONII Broth. sp. nov.

Dioicus; robustiusculus, caespitosus, caespitibus laxiusculis, pallide viridibus, opacis; *caulis* usque ad 6 mm longus, cum foliis c. 3 mm latus, infima basi fusco-radiculosus, dense foliosus, simplex; *folia* c. 15-juga, sicca homomalla, comalia circinato-incurva, humida erecto-patentia, stricta, elongate linearia, lanceolato-acuminata, mucronata, integerrima, elimbata, lamina vera paulum ultra medium folii producta, lamina dorsali ad basin nervi enata ibidemque rotundata, nervo crassiusculo, pallido, brevissima excedente, cellulis minutissimis, rotundato-hexagonis, pellucidis, laevissimis. Caetera ignota.

PANAY, Iloilo Province, Salug River, altitude 340 meters, *Bur. Sci. 18105 Robinson.* MINDANAO, Surigao Province, Agusan Valley, *For. Bur. 7607 Hutchinson.*

Species foliis elongate linearibus, lanceolato-acuminatis, cellulis pellucidis, laevissimis dignoscenda.

FISSIDENS NAGASAKINUS Besch. var. **LUZONENSIS** Broth. var. nov.

Folia superne minus angustata, nerve crassiore.

LUZON, Benguet Subprovince, *Merrill 7851.*

FISSIDENS NOBILIS Griff.

LUZON, Abra Province, Mount Posuey, *Bur. Sci. 27081 Ramos:* Benguet Subprovince, Baguio, *Baker 3843.*

CALYMPERACEAE

SYRRHOPODON Schwaegrichen

SYRRHOPODON ALBOVAGINATUS Schwaegr.

LUZON, Laguna Province, San Antonio, *Bur. Sci. 16670 Ramos.* BILIRAN, *Bur. Sci. 18464 McGregor.*

SYRRHOPODON MÜLLERI (Doz. et Molk.) Lac.

LUZON, Laguna Province, *Bur. Sci. 23272 McGregor.* MINDANAO, Lake Lanao, Camp Keithley, *Mrs. Clemens.*

SYRRHOPODON SUBULATUS Lac.

MINDANAO, Lake Lanao, Camp Keithley, *Mrs. Clemens.*
Area: Sumatra, Celebes, Borneo and New Guinea.

CALYMPERES Swartz

CALYMPERES SERRATUM A. Br.

LUZON, Laguna Province, Mount Maquiling, on trees, altitude 640 meters, *Bur. Sci. 17121 Robinson.*

Area: Ceylon, Sumatra, Java, Borneo, Labuan, Celebes, Hongkong and Samoa.

CALYMPERES ORIENTALE Mitt.

BILIRAN, *Bur. Sci. 18459 McGregor.*

POTTIACEAE

BARBULA Hedwig

BARBULA ORIENTALIS (Willd.) Broth.

LUZON, Laguna Province, Los Baños, on stone walls and on earth, altitude 10 meters, *Bur. Sci. 17138, 17140 Robinson;* Manila, *Bur. Sci. 18274 Robinson:* Rizal Province, Tanay, *Bur. Sci. 11882 Robinson & Ramos.* PANAY, Iloilo Province, Suague River, on walls, altitude 100 meters, *Bur. Sci. 18146 Robinson.*

BARBULA CONSANGUINEA (Thwait. et Mitt.) Jaeg.

LUZON, Rizal Province, Bosoboso, *Bur. Sci. 1166 Ramos:* Pangasinan Province, Umingan, *Bur. Sci. 18357 Otanes:* Ilocos Province, Bangui, on damp banks, *Bur. Sci. 27778 Ramos.*

Area: Ceylon, Singapore, Java and Luzon.

BARBULA INFLEXA (Dub.) C. Müll.

LUZON, Batangas Province, Taal Volcano, on very wet walls in ravines, altitude 80 meters, *Merrill 10608.* PANAY, Iloilo Province, Tigom River on rocks, altitude 150 meters, *Bur. Sci. 18052 Robinson.*

Area: Ceylon and Java.

HYOPHILA Bridel

HYOPHILA FLAVIPES Broth.

PANAY, Iloilo Province, Tigom River, on rocks, altitude 150 meters, *Bur. Sci. 18055 Robinson.* LUZON, Ifugao Subprovince, *Bur. Sci. 20041 McGregor.*

GYMNOSTOMIELLA Fleischer

GYMNOSTOMIELLA VERNICOSA (Hamp.) Fleisch.

LUZON, Laguna Province, Los Baños, on stone walls, altitude 10 meters, *Bur. Sci. 17139 Robinson.* PANAY, Iloilo Province, Tigom River, on rocks, altitude 150 meters, *Bur. Sci. 18051 Robinson.*

Area: Nepal, Burma, Java and Amboina.

GYMNOSTOMIELLA LONGINERVIS Broth. sp. nov.

Dioica; tenella, caespitosa, caespitibus densis, mollibus, late extensis, laete viridibus; *caulis* erectus, gracillimus, usque ad 8 mm longus, hic illic radiculis longis fuscis instructus, laxiuscule foliosus, simplex vel innovando ramosus; *folia* sicca contracta, humida patentia, comalia in rosulam congesta, e basi spathulata ovalia vel obovata, rotundato-obtusa, usque ad 0.76 mm longa et 0.30 mm lata, integerrima, nervo lutescente, infra summum apicem folii evanido, cellulis ovali-hexagonis, 0.015-0.020 mm longis, teneris, pellucidis, verrucosis, marginalibus minoribus, transverse dispositis, basilaribus rectangularibus, laevibus. Caetera ignota.

PANAY, Iloilo Province, Tigom River, on rocks, altitude 150 meters, *Bur. Sci. 18053 Robinson.*

Species a praecedente statura robustiore nec non foliorum forma et nervo multo longiore dignoscenda.

MERCEYOPSIS Brotherus et Dixon

MERCEYOPSIS MINUTA (Broth.) var. **SUBMINUTA** (Broth.) Broth. et Dix.

NEGROS, Mount Canlaon, *For. Bur. 17384 Curran.*

ORTHOTRICHACEAE

ANOECTANGIUM (Hedw.) Bryol. eur.

ANOECTANGIUM SUBALARUM Broth.

LUZON, Benguet Subprovince, Mount Pulog, *Bur. Sci. 16400 Curran, Merritt, Zchokke.*

MACROMITRIUM Bridel

MACROMITRIUM GONIORRHYNCHUM (Doz. et Molk.) Mitt.

LUZON, Pangasinan Province, Umingan, *Bur. Sci. 18358 Otanes:* Rizal Province, *Bur. Sci. 18321 Reillo.* PANAY, Iloilo Province, *Bur. Sci. 18217 Robinson.*

MACROMITRIUM ANGUSTIFOLIUM Bryol. jav.

LUZON, Bontoc Subprovince, *Vanoverbergh 398.*

MACROMITRIUM MERRILLII Broth.

LUZON, Tayabas Province, Mauban, on trees near sea, *Bur. Sci. 19396 Ramos:* Rizal Province, *Bur. Sci. 21348 Ramos.* PALAWAN, Taytay, *Merrill 8991.*

MACROMITRIUM SUBULIGERUM Bryol. jav.

LUZON, Laguna Province, San Antonio, *Bur. Sci. 14928, 16671 Ramos:* Tayabas Province, Mount Pular, on trees, *Bur. Sci. 19393 Ramos.* PANAY, Iloilo Province, Atimonan River, *Bur. Sci. 18167 Ramos.*

MACROMITRIUM SEMIPELLUCIDUM Doz et Molk.

LUZON, Laguna Province, San Antonio, on trees, *Bur. Sci. 20613 Ramos.* PANAY, Iloilo Province, Ulian River, on trees, altitude 400 meters, *Bur. Sci. 18260 Robinson.*

FUNARIACEAE

FUNARIA Schreber

FUNARIA CALVESCENS Schwaegr.

LUZON, Nueva Vizcaya Province, *Bur. Sci. 20228 McGregor.*

FUNARIA LUZONENSIS Broth.

LUZON, Bontoc Subprovince, *Vanoverbergh 745.*

BRYACEAE

WEBERA Hedwig

WEBERA SCABRIDENS (Mitt.) Jaeg.

LUZON, Benguet Subprovince, Baguio and vicinity, *Bur. Sci. 14095 Robinson.*

PSEUDOPOHLIA Williams

PSEUDOPOHLIA BULBIFERA Williams.

LUZON, Nueva Vizcaya Province, *Bur. Sci. 20231 McGregor.*
Area: Luzon.

PSEUDOPOHLIA MERRILLII Broth. sp. nov.

Dioica; gracilescens, caespitosa, caespitibus laxis, fuscescentibus, nitidiusculis; caulis 5-7 mm longus, infima basi fusco-radiculosus, dense foliosus, innovando ramosus, in axillis superioribus propagula turgide obovata, foliolis 4-5 ornata gerentia; *folia* sicca adpressa, humida erecto-patentia, comalia saepe homomalla, decurrentia, infima minora, dein sensim majora, elongate lanceolata, anguste acuminata, usque ad 2 mm longa et 0.35 mm lata, marginibus erectis vel anguste recurvis, apice serrulatis, nervo rufescente, continuo vel infra summum apicem folii evanido, cellulis elongatis, angustis; *seta* c. 2.5 cm alta, tenuis, lutescens; *theca* nutans, cum collo angusto sporangii fere longitudinis pyriformis, fusca; *peristomium* destructum.

NEGROS, Canlaon Volcano, *Merrill 6817*.

Species distinctissima, a praecedente foliorum forma nec non theca nutante, pyriformi longe diversa.

ANOMOBRYUM Schimper

ANOMOBRYUM GEMMIGERUM Broth.

LUZON, Bontoc Subprovince, *Vanoverbergh 727*.

BRACHYMENIUM Schwaegrichen

BRACHYMENIUM NEPALENSE Hook.

LUZON, Bontoc Subprovince, on trees, altitude 1,700 meters, *Vanoverbergh 2233:* Benguet Subprovince, Pauai, *Baker 1334*. CAMIGUIN DE MINDANAO, *Bur. Sci. 14899 Ramos*.

BRYUM (Dill.) Schimper

BRYUM COMPRESSIDENS C. Müll.

LUZON, Bontoc Subprovince, Bauco, *Vanoverbergh 93, 1770:* Batangas Province, Taal Volcano, on banks in very damp ravine on the outer slope of the cone, altitude 70 meters, *Merrill 10609*.

BRYUM CORONATUM Schwaegr.

LUZON, Bulacan Province, Angat, *Bur. Sci. 21860 Ramos*. DUMARAN, *Bur. Sci. 21643 Escritor*. PALAWAN, Taytay, *Merrill 8993*.

BRYUM AMBIGUUM Dub.

PANAY, Iloilo Province, *Bur. Sci. 18203 Robinson*.

BRYUM RAMOSUM (Hook.) Mitt.

LUZON, Benguet Subprovince, Pauai, *Baker 1324*.

RHODOBRYUM (Schimp.) Hampe

RHODOBRYUM GIGANTEUM (Hook.) Hamp.

LUZON, Bontoc Subprovince, Bauco, altitude 1,700 meters, *Vanoverbergh 1734:* Ifugao Subprovince, Mount Polis, *Bur. Sci. 20319 McGregor*.

MNIACEAE

ORTHOMNIUM Wilson

ORTHOMNIUM LOHERI Broth.

LUZON, Benguet Subprovince, Pauai, *Baker 1341;* Mount Pulog, *Merrill 6399.*

MNIUM (Dill.) Linnaeus

MNIUM SUCCULENTUM Mitt.

LUZON, Bontoc Subprovince, Bauco, near brooks, altitude 1,250 meters, *Vanoverbergh 1775.*

RHIZOGONIACEAE

HYMENODON Hooker f. et Wilson

HYMENODON SERICEUS (Doz. et Molk.) C. Müll.

LUZON, Laguna Province, summit of Mount Maquiling, *Baker 2753, 2755, Bur. Sci. 17027 Robinson.*

RHIZOGONIUM Bridel

RHIZOGONIUM SPINIFORME (L.) Bruch.

LUZON, Laguna Province, Mount Maquiling, on trees, altitude 670 to 1,000 meters, *Bur. Sci. 17015, 17047, 17038 Robinson, Baker:* Rizal Province, Mount Canumay, *Bur. Sci. 13796 Ramos:* Abra Province, Mount Posuey, on dead tree, *Bur. Sci. 27088 Ramos:* Bataan Province, *Bur. Sci. 22041 Medina:* Nueva Vizcaya Province, vicinity of Dupax, *Bur. Sci. 14341 McGregor.* CAMIGUIN DE MINDANAO, *Bur. Sci. 14892 Ramos.* PANAY, Iloilo Province, *Bur. Sci. 18206 Robinson.*

SPIRIDENTACEAE

SPIRIDENS Nees

SPIRIDENS REINWARDTII Nees.

BILIRAN, *Bur. Sci. 18455 McGregor.* LEYTE, Dagami, *Bur. Sci. 15396 Ramos.* CAMIGUIN DE MINDANAO, *Bur. Sci. 14904 Ramos.* JOLO, *Mrs. Clemens 9400.*

SPIRIDENS LONGIFOLIUS Lindb.

LUZON, Benguet Subprovince, Pauai, *Mrs. Clemens 9319, Baker 1330:* Ifugao Subprovince, Mount Polis, *Bur. Sci. 20329 McGregor.*

BARTRAMIACEAE

PHILONOTIS Bridel

PHILONOTIS GRIFFITHIANA (Wills.) Mitt.

CAMIGUIN DE MINDANAO, *Bur. Sci. 14891 Ramos.*

PHILONOTIS REVOLUTA Bryol. jav.

LUZON, Bontoc Subprovince, Bauco, *Vanoverbergh 1059, 1750, 1768:* Ifugao Subprovince, Mount Polis, *Bur. Sci. 20320, 20325 McGregor.*

PHILONOTIS SECUNDA (Doz. et Molk.) Bryol. jav.

LUZON, Ifugao Subprovince, *Bur. Sci. 20040 McGregor:* Nueva Vizcaya Province, *Bur. Sci. 20219 McGregor.* PANAY, Iloilo Province, Larena, on walls, altitude 820 meters, *Bur. Sci. 18204 Robinson.*

PHILONOTIS MOLLIS (Doz. et Molk.) Bryol. jav.

LUZON, Laguna Province, Los Baños, altitude 10 meters, *Bur. Sci. 17141 Robinson:* Rizal Province, Bosoboso, *Bur. Sci. 16962 Ramos.*

PHILONOTIS TURNERIANA (Schwaegr.) Mitt.

LUZON, Benguet Subprovince, Mount Tonglon, on banks, altitude about 1,900 meters, *Merrill 7868:* Laguna Province, summit of Mount Maquiling, *Baker 2748.*

Area: Nepal, Sikkim, Khasia, Java, Japan, Hawaii.

PHILONOTIS FALCATA (Hook.) Mitt.

LUZON, Benguet Subprovince, Pauai, *Mrs. Clemens 9320.*

Area: Himalaya, Tibet, Nilghiri, China, Japan.

BREUTELIA Schimper

BREUTELIA ARUNDINIFOLIA (Dub.) Broth.

LUZON, Benguet Subprovince, Pauai, *Mrs. Clemens 9315.*

NECKERACEAE

ENDOTRICHELLA C. Müller

ENDOTRICHELLA ELEGANS (Doz. et Molk.) Fleisch.

BILIRAN, *Bur. Sci. 18472 McGregor.* BASILAN, *Bur. Sci. 16273 Reillo.* PANAY, Iloilo Province, Larena, on dead wood, altitude 750 meters, *Robinson.* LUZON, Ifugao Subprovince, Mount Polis, *Bur. Sci. 20321 McGregor:* Benguet Subprovince, Pauai, *Baker 1332.* PALAWAN, Cabinbin River, *Weber 1568.*

ENDOTRICHELLA PERPLICATA Broth.

LUZON, Rizal Province, *Bur. Sci. 19318 Reillo:* Ifugao Subprovince, *Bur. Sci. 20324 McGregor.*

ENDOTRICHELLA ELMERI Broth.

SAMAR, *Bur. Sci. 17656 Ramos.*

GAROVAGLIA Endlicher

GAROVAGLIA BAKERI Broth. sp. nov.

Robustiuscula, rigidissima, laete viridis, hic illic rufescens, nitida, *caules secundarii* numerosi, adscendentes, superne arcuati, usque ad 10 cm longi, densissime foliosi, subteretes, simplices, obtusi; *folia* sicca imbricata, undulata basi plicata humida suberecta, concava, ovato-oblonga, raptim in acumen lanceolato-subulatum attenuata, superne minute, in acumen argute serrata, enervia, cellulis incrassatis, lumine lineari-elliptico, inferioribus sensim longioribus et angustioribus, alaribus sat numerosis ovalibus vel subquadratis, omnibus laevissimis; *bracteae perichaetii* convolutaceae, superne latiores, rotundatae, brevissime cuspidatae, integrae vel subintegrae. Caetera ignota.

LUZON, Laguna Province, Mount Banahao, *Baker 2324.*

Species *G. undulatae* Ren. et Card. affinis, sed statura minore, rigiditate foliorumque forma optime diversa.

GAROVAGLIA PERUNDULATA Broth. sp. nov.

Gracilis, rigida, laete viridis, nitida; *caules secundarii* nemorosi, arcuato-adscendentes, usque ad 6 cm longi, densissime foliosi, complanati, simplices, obtusi; *folia* sicca imbricata, undulata, humida concava, breviter oblonga, raptim in acumen lanceolato-subulatum attenuati, acumine plus minusve serrulato, enervia, cellulis haud incrassatis, rhomboideis, basin versus sensim longioribus et angustioribus, alaribus numerosis, subquadratis, aureis, omnibus laevissimis. Caetera ignota.

LUZON, Ifugao Subprovince, Mount Polis, *Bur. Sci. 19917 McGregor.*

Species distinctissima, praecedenti affinis, sed statura gracili foliisque cellulis leptodermibus facillime dignoscenda.

GAROVAGLIA PLICATA (Nees) Endl. var. **GRACILESCENS** Broth. var. nov.

Gracilescens; *caules secundarii* usque ad 11 cm longi, laxius foliosi; folia lateralia arcuato-patentia.

LUZON, Nueva Vizcaya Province, *Bur. Sci. 20224 McGregor.*

FLORIBUNDARIA C. Müller

FLORIBUNDARIA FLORIBUNDA (Doz. et Molk.) Fleisch.

PALAWAN, Cabinbin River, on boulders, *Weber 1566.*

PAPILLARIA (C. Müll.) C. Müller

PAPILLARIA FUSCESCENS (Hook.) Jaeg.

LUZON, Abra Province, Mount Posuey, on trees, *Bur. Sci. 27093 Ramos.*

AËROBRYOPSIS Fleischer

AËROBRYOPSIS LANOSA (Mitt.) Broth.

PANAY, Iloilo Province, Larena, on *Ficus*, altitude 820 meters, *Bur. Sci. 18207 Robinson.* MINDANAO, Butuan Subprovince, *Weber 1321.*

BARBELLA (C. Müll.) Fleischer

BARBELLA PENDULA (Sull.) Fleisch.

LUZON, Benguet Subprovince, Pauai, *Mrs. Clemens 9318:* Ifugao Subprovince, Mount Polis, *Bur. Sci. 20312 McGregor.*

BARBELLA (EUBARBELLA) CLEMENSIAE Broth. sp. nov.

Gracilescens, mollis, aureo-flava sericeo-nitens; *caules secundarii* longissimi, penduli, flexuosi, laxe foliosi, remote subpinnatim ramosi, ramis patulis, usque ad 2 cm vel paulum ultra longis, flexuosis, laxe foliosis, complanatis, plerumque plus minusve distincte attenuatis, simplicibus vel parce ramulosis; *folia caulina* adpressa, ovato-lanceolata, in subulam piliformem sensim attenuata, ubique minute denticulata, nervo tenui, ultra medium folii evanido, cellulis anguste linearibus, papilla minutissima plerisque medio instructis, basilaribus infimis multo latiori-

bus, alaribus sat numerosis oblongis, rufescentibus; *folia ramea* patula, magis concava, brevius acuminata. Caetera ignota.

LUZON, Benguet Subprovince, Pauai, *Mrs. Clemens 9317.*

Species habitu *B. bombycinae* (Ren. et Card.) Fleisch. valde similis, sed foliorum forma dignoscenda.

BARBELLA ENERVIS (Mitt.) Fleisch.

LUZON, Benguet Subprovince, Pauai, *Baker 1329.*

METEORIUM (Doz. et Molk.) Fleischer

METEORIUM MIQUELIANUM (C. Müll.) Fleisch.

LUZON, Pampanga Province, Mount Arayat, *Bur. Sci. 22450 Ramos:* Ifugao Subprovince, Mount Polis, *Bur. Sci. 20303 McGregor.* PANAY, Iloilo Province, Ulian River, on trees, altitude 400 meters, *Bur. Sci. 18257 Robinson.*

METEORIUM HELMINTHOCLADUM (C. Müll.) Fleisch.

LUZON, Ifugao Subprovince, Mount Polis, *Bur. Sci. 19937 McGregor:* Benguet Subprovince, Pauai, *Baker 1325.*

METEORIOPSIS Fleischer

METEORIOPSIS RECLINATA (C. Müll.) Fleisch.

LUZON, Bontoc Subprovince, Bauco, altitude 1,250 meters, *Vanoverbergh 1743:* Nueva Vizcaya Province, *Bur. Sci. 20223 McGregor:* Ifugao Subprovince, Mount Polis, *Bur. Sci. 20306 McGregor:* Rizal Province, *Bur. Sci. 19322 Reillo.*

f. **PILIFER** Fleisch.

LUZON, Nueva Vizcaya Province, vicinity of Dupax, *Bur. Sci. 14345 McGregor.*

TRACHYPODOPSIS Fleischer

TRACHYPODOPSIS CRISPATULA (Hook.) Fleisch.

LUZON, Abra Province, Mount Posuey, *Bur. Sci. 27097 Ramos:* Ifugao Subprovince, Mount Polis, *Bur. Sci. 19926 McGregor.*

CALYPTOTHECIUM Mitten

CALYPTOTHECIUM TUMIDUM (Mitt.) Fleisch.

BILIRAN, *Bur. Sci. 18454, 18456 McGregor.*

NECKEROPSIS Reichardt

NECKEROPSIS LEPINEANA (Mont.) Fleisch.

BILIRAN, *Bur. Sci. 18462 McGregor.* PANAY, Iloilo Province, *Bur. Sci. 18178 Robinson.* LUZON, Laguna Province, Mount Maquiling, *Bur. Sci. 17122 Robinson;* Nueva Vizcaya Province, vicinity of Dupax, *Bur. Sci. 14351 McGregor.*

NECKEROPSIS GRACILENTA (Bryol. jav.) Fleisch.

PANAY, Iloilo Province, *Bur. Sci. 18240 Robinson.*

NECKEROPSIS CRINITA (Griff.) Fleisch.

MINDANAO, Butuan Subprovince, *Weber 1290.*

HIMANTHOCLADIUM (Mitt.) Fleischer

HIMANTHOCLADIUM LORIFORME (Bryol. jav.) Fleisch.

BASILAN, *Bur. Sci. 16278 Reillo.* BILIRAN, *Bur. Sci. 18470, 18465 McGregor.* LUZON, Rizal Province, *Bur. Sci. 19317 Reillo.*

HOMALIODENDRON Fleischer

HOMALIODENDRON FLABELLATUM (Dicks.) Fleisch.

LUZON, Rizal Province, *Bur. Sci. 19326 Reillo.* BILIRAN, *Bur. Sci. 18471 McGregor.*

HOMALIODENDRON SCALPELLIFOLIUM (Mitt.) Fleisch.

LUZON, Benguet Subprovince, Baguio, *Baker 3852.*

THAMNIUM Schimper

THAMNIUM ELLIPTICUM (Bryol. jav.) Kindb.

LUZON, Laguna Province, Mount Maquiling, *Bur. Sci. 17215 Robinson.*

ENTODONTACEAE

ENTODON C. Müller

ENTODON LONGIDENS Broth.

LUZON, Ifugao Subprovince, *Bur. Sci. 20045 McGregor:* Nueva Vizcaya Province, *Bur. Sci. 20229 McGregor.*

ENTODON RUBICUNDUS (Wils.) Jaeg.

LUZON, Bontoc Subprovince, *Vanoverbergh 1319.*

Area: Himalaya, Khasia, Bhotan, and the Andaman Islands.

ERYTHRODONTIUM Hampe

ERYTHRODONTIUM SQUARRULOSUM (Mont.) Par.

LUZON, Pangasinan Province, Umingan, *Bur. Sci. 18359 Otanes.*

TRACHYPHYLLUM Gepp

TRACHYPHYLLUM INFLEXUM (Harv.) Gepp.

LUZON, Pangasinan Province, San Quintin, *Bur. Sci. 5661, 5577 Otanes;* Umingan, *Bur. Sci. 18360 Otanes.*

Area: Central India, Nepal, Sikkim, Ava and Pegu.

HOOKERIACEAE

CALLICOSTELLA (C. Müll.) Mitten

CALLICOSTELLA PAPILLATA (Mont.) Mitt.

LUZON, Laguna Province, Mount Maquiling, *Bur. Sci. 17195, 17196, 17205, 17204 Robinson;* Los Baños, *Bur. Sci. 14148 Robinson:* Rizal Province, Mount Canumay, *Bur. Sci. 18798 Ramos.* BILIRAN, *Bur. Sci. 18466 McGregor.*

DISTICHOPHYLLUM Dozy et Molkenboer

DISTICHOPHYLLUM NIGRICAULE Mitt.

LUZON, Laguna Province, Mount Maquiling, *Bur. Sci. 17082 Robinson.*

Area: Java.

LESKEODON Brotherus

LESKEODON PHILIPPINENSIS Broth. sp. nov.

Synoicus; robustus, caespitosus, caespitibus densis, mollibus, pallide viridibus, subopacis; *caulis* usque ad 2.5 cm longus, plus minusve alte fusco-radiculosus, dense et complanate foliosus, cum foliis c. 5 mm latus, simplex, obtusus; *folia lateralia* patula, e basi brevissime spathulata oblonga, breviter acuminata, in subulam piliformem attenuata, lamina c. 3 mm longa et c. 1.3 mm lata, limbata, integerrima, nervo tenui, in subulam usque ad 0.8 mm longam continuo, cellulis superioribus rotundato-hexagonis. 0.025-0.030 mm, marginem versus multo minoribus, basilaribus oblongo-hexagonis, marginalibus limbum inferne triseriatum, superne angustiorem, hyalinum efformantibus; *seta* c. 2 mm alta, rubra, summo apice mamillis grossis scabra; *theca* erecta, minuta, ovalis, pallide fuscidula; *exostomii* dentes pallidi, lanceolato-subulati, c. 0.5 mm longi, dense lamellati, papillosi; *processus* dentium longitudinis, lineari-lanceolati, papillosi; *spori* 0.010-0.015 mm, laeves; *operculum* e basi convexo-conica breviter rostratum; *calyptra* operculum tantum obtegens, glabra, basi pilis longis densisque instructa.

BILIRAN, *Bur. Sci. 18468 McGregor.*

Species pulcherrima, cum *L. acuminato* (Bryol. jav.) Fleisch. comparenda, sed foliorum forma cellulisque laxioribus dignoscenda.

CHAETOMITRIUM Dozy et Molkenboer

CHAETOMITRIUM PHILIPPINENSE (Mont.) Bryol. eur.

PANAY, Iloilo Province, Atimonan River, on tree, altitude 300 m, *Bur. Sci. 18164 Robinson.*

CHAETOMITRIUM PAPILLIFOLIUM Bryol. jav.

LUZON, Nueva Vizcaya Province, vicinity of Dupax, *Bur. Sci. 14348 McGregor.*

CHAETOMITRIUM ORTHORRHYNCHUM (Doz. et Molk.) Bryol. jav.

BASILAN, Cumalarang, *Bur. Sci. 16267 Reillo.*

ERIOPUS (Brid.) C. Müller

ERIOPUS FLACCIDUS Broth. sp nov.

Dioicus; gracilescens, caespitosus, caespitibus laxis, sordide viridibus, vernicosus; *caulis* usque ad 6 cm longus, plus minusve alte fusco-radiculosus, laxe et complanate foliosus, plerumque attenuatus, simplex vel divisus; *folia* sicca contracta, facillime emollita, flaccida, lateralia patula, asymmetrica, e basi brevissime spathulata late oblonga, obtusa, mucronata, c. 5 mm longa et c. 2 mm lata, supra medium argute serrata, nervis binis, uno crasso, brevi, altero saepe nullo, cellulis superioribus c. 0.060 mm longis et c. 0.030 mm latis, basin versus sensim longioribus, marginalibus elongatis, angustis, limbum triseriatum, lutescentem efformantibus; folia dorsalia et ventralia multo minora, late ovalia; bracteae perichaetii late ovalis, vaginantes, raptim in acumen subulatum attenuatae; *seta* c. 8 mm alta, pallida, ubique setosa, ciliis superne usque ad 0.125 mm longis, basin versus brevioribus; *theca* horizontalis, minuta, ovalis, atrofusca. Caetera ignota.

LUZON, Laguna Province, Mount Banahao, *Merrill 7523.*

Species *E. ramoso* Fleisch. affinis, sed foliis flaccidis nec non seta ciliis duplo brevioribus instructa optime diversa.

LESKEACEAE

PSEUDOLESKEOPSIS Brotherus

PSEUDOLESKEOPSIS DECURVATA (Mitt.) Broth.

LUZON, Nueva Vizcaya Province, vicinity of Dupax, *Bur. Sci. 14346 McGregor.*

PSEUDOLESKEOPSIS ACUTISSIMA Broth. sp. nov.

Species praecedenti habitu simillima, sed foliis late ovatis, acutissimis, plerumque cellula hyalina terminatis dignoscenda.

LUZON, Rizal Province, San Isidro, on wet rock by streams, *Bur. Sci. 5172 Foxworthy.*

PELEKIUM Mitten

PELEKIUM VELATUM Mitt.

LUZON, Laguna Province, Mount Maquiling, *Bur. Sci. 17201, 17230 Robinson;* Los Baños, *Baker 698, 2399.* PANAY, Iloilo Province, Tigom River, on dead wood, altitude 160 meters, *Bur. Sci. 18049 Robinson.*

THUIDIUM Bryol. eur.

THUIDIUM TAMARISCELLUM (C. Müll.) Bryol. jav.

LUZON, Benguet Subprovince, *Bur. Sci. 12939 Fénix:* Bontoc Subprovince, *Vanoverbergh 396.*

Area: Nilghiri, Tonkin, Sumatra and Luzon.

THUIDIUM TRACHYPODUM (Mitt.) Bryol. jav.

LUZON, Laguna Province, Mount Maquiling, *Bur. Sci. 17212 Robinson.* PANAY, Iloilo Province, *Bur. Sci. 18130 Robinson.*

THUIDIUM MEYENIANUM (Hamp.) Bryol. jav.

LUZON, Ifugao Subprovince, *Bur. Sci. 20044 McGregor.*

THUIDIUM BIFARIUM Bryol. jav.

PANAY, Iloilo Province, Atimonan River, on rocks, altitude 475 meters, *Bur. Sci. 18158 Robinson;* Salug River, on sandstone, altitude 340 meters, *Bur. Sci. 18099, 18101, 18104, 18107 Robinson.*

Area: Java and Sumatra.

THUIDIUM CYMBIFOLIUM (Doz. et Molk.) Bryol. jav.

LUZON, Ifugao Subprovince, Mount Polis, *Bur. Sci. 20314 McGregor:* Rizal Province, *Bur. Sci. 19325 Reillo:* Nueva Vizcaya Province, vicinity of Dupax, *Bur. Sci. 14350 McGregor.* PALAWAN, Cabinbin River, on rocks along streams, *Weber 1569.*

THUIDIUM PLUMULOSUM (Doz. et Molk.) Bryol. jav.

SAMAR, *Bur. Sci. 17620 Ramos.* CAMIGUIN DE MINDANAO, *Bur. Sci. 14895 Ramos.* LUZON, Laguna Province, Los Baños, on rocks, *Baker 760, 702, 2382.*

THUIDIUM CASUARINUM (C. Müll.) Jaeg.

LUZON, Rizal Province, Mount Canumay, *Bur. Sci. 13799 Ramos.*

HYPNACEAE

CAMPYLIUM (Sull.) Bryhn.

CAMPYLIUM GLAUCOCARPUM (Reinw.) Broth.

LUZON, Bontoc Subprovince, Bauco, *Vanoverbergh 2871:* Benguet Subprovince, Pauai, *Baker 1331:* Ifugao Subprovince Mount Polis, *Bur. Sci. 19922, 20301, 20307, 20310 McGregor:* Abra Province, Mount Posuey, *Bur. Sci. 27098 Ramos.*

CTENIDIUM (Schimp.) Mitten

CTENIDIUM FORSTENII (Bryol. jav.) Broth.

LUZON, Bontoc Subprovince, *Vanoverbergh 1275.*
Area: Celebes.

LEPTOHYMENIUM Schwaegrichen

LEPTOHYMENIUM TENUE (Hook.) Schwaegr.

LUZON, Benguet Subprovince, Pauai, *Mrs. Clemens 9316.*

MACROTHAMNIUM Fleischer

MACROTHAMNIUM MACROCARPUM (Reinw. et Hornsch.) Fleisch.

LUZON, Laguna Province, Mount Banahao, *Baker 827.*

ELMERIOBRYUM Brotherus

ELMERIOBRYUM PHILIPPINENSE Broth.

LUZON, Benguet Subprovince, Pauai, *Baker 1340:* Ifugao Subprovince, Mount Polis, *Bur. Sci. 20309 McGregor.*

ECTROPOTHECIUM Mitten

ECTROPOTHECIUM MONUMENTORUM (Dub.) Jaeg.

LUZON, Panay Iloilo Province, Salug River, on rocks, altitude 280 meters, *Bur. Sci. 18090, 18103, 18218 Robinson.*

ECTROPOTHECIUM ASSIMILE Broth.

PANAY, Iloilo Province, Tigom River, on rocks, altitude 150 meters, *Bur. Sci. 18048, 18054 Robinson;* Salug River, on trees, altitude 500 meters, *Bur. Sci. 18128, 18143 Robinson.*

ECTROPOTHECIUM MICROPYXIS Broth.

LUZON, Laguna Province, Mount Maquiling near Los Baños, *Baker 2611:* Ifugao Subprovince, Mount Polis, *Bur. Sci. 19921 McGregor.* MINDANAO, Butuan Subprovince, *Weber 1310.*

ECTROPOTHECIUM LUZONIAE (C. Müll.) Broth.

LUZON, Ifugao Subprovince, Mount Polis, *Bur. Sci. 19923, 19935, 20308, 20311 McGregor.*

ECTROPOTHECIUM FERRUGINEUM (C. Müll.) Jaeg.

LUZON, Laguna Province, Mount Maquiling, on trees, and on rocks, altitude 600 to 750 meters, *Bur. Sci. 17011, 17017, 17030, 17046, 17049 17058 Robinson.*

Area: Luzon.

ECTROPOTHECIUM SUBINTORQUATUM Broth.

LUZON, Ifugao Subprovince, Mount Polis, *Bur. Sci. 19920, 20307 McGregor:* Laguna Province, Mount Maquiling, on trees, altitude 850 meters, *Bur. Sci. 17066 Robinson.*

ECTROPOTHECIUM ELEGANTI-PINNATUM (C. Müll.) Jaeg.

PANAY, Iloilo Province, near Camp Larena, altitude 800 meters, *Bur. Sci. 18195* and Larena, on *Ficus*, altitude 850 meters, *Bur. Sci. 18209 Robinson.* PALAWAN, Cabinbin River, on decaying logs, *Weber 1564.* LUZON, Laguna Province, Mount Banahao, *Bur. Sci. 9862 Robinson.*

ECTROPOTHECIUM ELMERI Broth.

LUZON, Ifugao Subprovince, Mount Polis, *Bur. Sci. 19924 McGregor.*

ECTROPOTHECIUM CALLICHROIDES (C. Müll.) Jaeg.

LUZON, Laguna Province, Mount Maquiling, on wood, living and dead, altitude 780 meters, *Bur. Sci. 17101 Robinson.*

ECTROPOTHECIUM BRACHYPHYLLUM Broth. sp. nov.

Dioicum; robustum, caespitosum, caespitibus densis, rigidis, pallide lutescenti-viridibus, nitidis; *caulis* elongatus, densiuscule foliosus, irregulariter vel remote foliosus, ramis patulis, inaequalibus, valde complanatis, simplicibus, raro longioribus, parce ramulosis; *folia* falcatula, e basi oblonga breviter lanceolato-acuminata, apice serrulata, nervis, binis, brevibus vel obsoletis, cellulis angustissime linearibus, alaribus vix ullis, omnibus laevissimis; *bracteae perichaetii* longius acuminatae, superne serrulatae. Caetera ignota.

LUZON, Bontoc Subprovince, *Vanoverbergh 1272:* Benguet Subprovince, Mount Tonglon, on boulders in forest, altitude about 2,000 meters, *Merrill 7838.*

Species *E. buitenzorgii* (Bél.) Jaeg. valde affinis.

ECTROPOTHECIUM ICHNOTOCLADUM (C. Müll.) Jaeg.

LUZON, Benguet Subprovince, Lutab to Kabayan, *Bur. Sci. 8788 McGregor.*

Area: Sikkim, Sumatra, Java, Borneo, Celebes, and Amboina.

ECTROPOTHECIUM CYPEROIDES (Hook.) Jaeg.

LUZON, Tayabas Province, Guinayangan, *Bur. Sci. 20919 Escritor:* Cagayan Province, Abulug River, *Weber 1589:* Laguna Province, Los Baños, *Baker 2381, 2384, 2378.* MINDANAO, Bukidnon Subprovince, *Weber 1505.*

TRISMEGISTIA (C. Müll.) Brotherus

TRISMEGISTIA LANCIFOLIA (Harv.) Broth.

LUZON, Laguna Province, San Antonio, on trees, *Bur. Sci. 16669 Ramos.* MINDANAO, Misamis Province, *For. Bur. 17950 Miranda.* BASILAN, *Bur. Sci. 16266 Reillo.*

TRISMEGISTIA RIGIDA (Hornsch. et Reinw.) Broth.

LUZON, Laguna Province, Mount Maquiling, *For. Bur. 20854 Villamil;* Mount Banahao, *Baker 2326.* CAMIGUIN DE MINDANAO, *Bur. Sci. 14900 Ramos.*

ISOPTERYGIUM Mitten

ISOPTERYGIUM ALBESCENS (Schwaegr.) Jaeg.

LUZON, Laguna Province, Mount Banahao, *Baker.*

ISOPTERYGIUM MINUTIRAMEUM (C. Müll.) Jaeg.

LUZON, Laguna Province, Mount Maquiling, on stones, altitude 700 meters, *Bur. Sci. 17023 Robinson,* and on dead wood, *Bur. Sci. 17029 Robinson.*

Area: Java, Banca and Borneo.

ISOPTERYGIUM TAXIRAMEUM (Mitt.) Jaeg.

PANAY, Iloilo Province, *Bur. Sci. 18154 Robinson;* Tinayoc, on earth, altitude 210 meters, *Bur. Sci. 18035 Robinson,* and Tigom River, on trees, altitude 170 meters, *Bur. Sci. 18050 Robinson.*

Area: Himalaya, Khasia, Ceylon, Sumatra, Formosa, Assam and Japan:

VESICULARIA (C. Müll.) C. Müller

VESICULARIA RETICULATA (Doz. et Molk.) Broth.

LUZON, Laguna Province, Mount Maquiling, *Baker 2586.*

VESICULARIA CAMPYLOTHECIUM (Broth.) Broth.

LUZON, Laguna Province, Mount Maquiling, *Baker 2586:* Rizal Province, Antipolo, *Bur. Sci. 20996 Ramos.*

VESICULARIA MEYENIANA (Hamp.) Broth.

LUZON, Laguna Province, Mount Maquiling, *Bur. Sci. 17203 Robinson.* PANAY, Iloilo Province, Suague River, on rocks, altitude 225 meters, *Bur. Sci. 18151 Robinson.* BILIRAN, *Bur. Sci. 18467 McGregor.*

VESICULARIA SUCCOSA (Mitt.) Broth.

LUZON, Nueva Vizcaya Province, vicinity of Dupax, *Bur. Sci. 14340 McGregor.*

Area: Nepal and Sikkim.

VESICULARIA FILICUSPES Broth.

LUZON, Laguna Province, Mount Banahao, *Baker 2333.* CAMIGUIN DE MINDANAO, *Bur. Sci. 14889 Ramos.*

TAXITHELIUM Spruce

TAXITHELIUM INSTRATUM (Brid.) Broth.

LUZON, Laguna Province, Mount Maquiling, *Bur. Sci. 17928 Brown.* PANAY, Iloilo Province, *Bur. Sci. 18145 Robinson.*

TAXITHELIUM NEPALENSE (Schwaegr.) Broth.

LUZON, Rizal Province, *Bur. Sci. 21344, 21342 Ramos:* Laguna Province,

Los Baños, on stones in creek, *Baker 42:* Batangas Province, *Bur. Sci. 22412 Ramos.* PANAY, Iloilo Province, Santa Barbara, on *Mangifera indica*, altitude 25 meters, *Bur. Sci. 18145 Robinson.*

TAXITHELIUM (POLYSTIGMA, APTERA) BAKERI Broth. sp. nov.

Antoicum; tenellum, caespitosum, caespitibus densis, depressis, cortici adnatis, laete viridibus, aetate lutescentibus, opacis; *caulis* elongatus, repens, dense et regulariter pinnatim ramosus, ramis patulis, vix ultra 3 mm longis, valde complanatis, dense foliosis, cum foliis vix ultra 1 mm latis, simplicibus, obtusis; *folia* lateralia patula, concaviuscula, ovato-lanceolata, subintegra, enervia, cellulis anguste linearibus, dense seriatim papillosis, marginalibus brevioribus et latioribus, laevissimis, alaribus vix diversis. Caetera ignota.

LUZON, Laguna Province, Los Baños, *Baker 2379, 2400.*

Species *T. Kaernebachii* (Broth.) Broth. valde affinis, sed foliis longius acuminatis dignoscenda.

TAXITHELIUM (POLYSTIGMA) ROBINSONII Broth. sp. nov.

Antoicum; tenellum, caespitosum, caespitibus densis, mollibus, late extensis, lutescenti-viridibus, sericeo-nitidis; *caulis* elongatus, repens, per totam longitudinem fusco-radiculosus, dense ramosus, ramis adscendentibus, vix ultra 5 mm longis, densiuscule foliosis, complanatis, simplicibus, obtusis; *folia* patentia concaviuscula e basi contracta ovato-lanceolata, breviter subulato-acuminata, superne argute serrata, enervia, cellulis angustissimis, superioribus indistincte et tenerrime seriatim papillosis, alaribus vesiculosis paucissimis; *bracteae perichaetii* internae e basi vaginante subsensim longe subulatae, superne argute serratae; *seta* usque ad 2.5 cm alta, tenuissima, rubra, laevissima; *theca* inclinata, minuta, asymmetrica, sicca sub ore constricta, fusca. Caetera ignota.

LUZON, Laguna Province, Mount Banahao, *Bur. Sci. 9820, 9864 Robinson.*

Species *T. benguetiae* Broth. affinis, sed foliis superne argute serratis, cellulis indistincte seriatim papillosis nec non seta multo longiore optime diversa.

TAXITHELIUM PERCAPILLIPES Broth.

LUZON, Tayabas Province, Mount Pular, *Bur. Sci. 19431 Ramos.*

TAXITHELIUM LINDBERGII (Bryol. jav.) Ren. et Card.

LUZON, Laguna Province, Mount Maquiling, on trees, altitude 650–700 meters, *Bur. Sci. 17031, 17100 Robinson:* Camarines Province, Mount Cauayan, *Bur. Sci. 22166 Ramos.*

TAXITHELIUM ALARE Broth.

LUZON, Laguna Province, Mount Maquiling, on trees, altitude 900 meters, *Bur. Sci. 17077 Robinson:* Ifugao Subprovince, Mount Polis, *Bur. Sci. 19919 McGregor.* CAMIGUIN DE MINDANAO, *Bur. Sci. 14894 Ramos.*

TAXITHELIUM BENGUETIAE Broth.

LUZON, Nueva Vizcaya Province, *Bur. Sci. 20226 McGregor.*

TAXITHELIUM (LIMNOBIELLA) MERRILLII Broth. sp. nov.

Antoicum; robustiusculum, caespitosum, caespitibus densis, sordide fusco-viridibus, opacis; *caulis* elongatus, repens, laxe foliosus, inferne parce, superne densius pinnatim ramosus, ramis patulis, vix ultra 5 mm longis, densiuscule foliosis, complanatis, cum foliis usque ad 1.9 mm latis, simplicibus, attenuatulis vel obtusis; *folia* ramea lateralia patula, concava, e basi contracta ovalia, obtusiuscula, plerumque apiculata, apice minutissime serrulata, nervis binis, brevissimis, plerumque obsoletis, cellulis linearibus, superioribus indistincte et tenerrime seriatim papillosis, alaribus paucis vesiculosis, supra alaribus paucis subquadratis; *seta* c. 1.5 cm alta, tenuis, rubra. Caetera ignota.

PALAWAN, Taytay, *Merrill 8992.*

TAXITHELIUM PAPILLATUM (Harv.) Broth.

LUZON, Cagayan Province, *Bur. Sci. 14585 Ramos.* BILIRAN, *Bur. Sci. 18460, 18469 McGregor.*

LEUCOMIACEAE

LEUCOMIUM Mitten

LEUCOMIUM ANEURODICTYON (C. Müll.) Jaeg.

LUZON, Laguna Province, Mount Maquiling, *Bur. Sci. 17212 Robinson.*
Area: Sumatra, Java, Borneo and Amboina.

SEMATOPHYLLACEAE

MEIOTHECIUM Mitten

MEIOTHECIUM MICROCARPUM (Harv.) Mitt.

LUZON, Nueva Vizcaya Province, vicinity of Dupax, *Bur. Sci. 14847 McGregor.*

MEIOTHECIUM JAGORI (C. Müll.) Broth.

CAMIGUIN DE MINDANAO, *Bur. Sci. 14897 Ramos.*

MEIOTHECIUM OBTUSUM Broth. sp. nov.

Antoicum; robustiusculum, pallide fuscescenti-viride, nitidum; *caulis* elongatus repens, per totam longitudinem hic illic fusco-radiculosus, dense foliosus, plus minusve dense pinnatim ramosus, ramis teretibus, simplicibus, c. 1-2 cm longis vel longioribus, parce ramulosis; *folia* sicca imbricata, suberecta, concava, laevia, elongate oblonga, breviter acuminata, apice recurvo, obtuso, marginibus late recurvis, integerrimis, enervia, cellulis valde incrassatis, lumine angustissimo, alaribus oblongis, vesiculosis, omnibus laevissimis; *seta* c. 5 mm alta, tenuissima, rubra, superne mamillis humillimis, latis instructa; *theca* horizontalis, minuta, oblonga, fusca. Caetera ignota.

LUZON, Laguna Province, summit of Mount Maquiling, *Baker 2762.*
Species *M. fornicato* (Card.) Broth. valde affinis, sed foliis angustioribus, acumine angustiore dignoscenda.

RHAPHIDOSTEGIUM (Bryol. eur.) de Notaris

RHAPHIDOSTEGIUM SAPROXYLOPHILUM (C. Müll.) Jaeg.

LUZON, Laguna Province, San Antonio, on bamboo, *Bur. Sci. 16673 Ramos:* Rizal Province, *Bur. Sci. 21341 Ramos.*

RHAPHIDOSTEGIUM (APTYCHUS) LUZONENSE Broth. sp. nov.

Rhaphidostegium tristiculum Broth. in Philip. Journ. Sci. 8 (1913) Bot. 93 nec (Mitt.) Jaeg.

Antoicum; robustum, caespitosum, caespitibus densis, lutescentibus, sericeo-nitidis; *caulis* elongatus, repens, per totam longitudinem fusco-radiculosus, dense foliosus, dense pinnatim ramosus, ramis arcuato-adscendentibus, simplicibus, obtusis; *folia* homomalla, concava, oblongo-elliptica, lanceolato-acuminata, marginibus late recurvis, integerrimis vel apice remote et minutissime serrulatis, enervia, cellulis elongatis, angustis, haud incrassatis, pellucidis, basilaribus infimis brevioribus, aureis, alaribus vesiculaeformibus, supraalaribus laxe subquadratis, aureis, omnibus laevissimis; *bracteae perichaetii* internae erectae, vaginantes, subsensim lanceolato-acuminatae, integrae; *seta* c. 1 cm alta, tenuissima, rubra, laevissima; *theca* subhorizontalis, e collo breviusculo ovalis vel oblonga, minuta, sicca deoperculata sub ore constricta, fusca; *operculum* longe rostratum.

LUZON, Benguet Subprovince, *Sanchez 6, 11, For. Bur. 15639 Curran;* Baguio and vicinity, *Bur Sci. 14053 Robinson.*
Species *Rh. subhumili* (C. Müll.) Jaeg. et *Rh. phaeniceo* (C. Müll.) Jaeg. affinis sed statura multo robustiore oculo nudo jam dignoscenda, a *Rh. tristiculo* (Mitt.) Jaeg., quocum olium confusi, cellulis angustioribus, pellucidis diversa.

TRICHOSTELEUM (Mitt.) Jaeger

TRICHOSTELEUM HAMATUM (Doz. et Molk.) Jaeg.

LUZON, Laguna Province, Mount Maquiling, altitude 660 to 1,000 meters, *Bur. Sci. 17009, 17028, 17070, 17150, 17106 Robinson;* Mount Banahao, *Baker 2825.*

Var. **SEMIMAMILLOSUM** (C. Müll.) Par.

LUZON, Laguna Province, Mount Maquiling, on trees, altitude 700 meters, *Bur. Sci. 17021 Robinson:* Abra Province, Mount Posuey, *Bur. Sci. 27096 Ramos.*

TRICHOSTELEUM (PAPILLIDIUM) BASILANENSE Broth. sp. nov.

Antoicum: tenellum, caespitosum, caespitibus densis, depressis, lutescenti-fuscescentibus, nitidiusculis; *caulis* elongatus, repens, per totam longitudinem fusco-radiculosus, dense pinnatim ramosus, ramis dense foliosis, complanatis, brevibus, simplicibus vel longioribus parce ramulosis; *folia* patentia, concava, e basi contracta elongate et anguste elliptico-oblonga, in acumen subloriforme, plerumque semitortum sensim attenuata, marginibus late recurvis, inferne minute, superne argute serratis, enervia, cellulis anguste ellipticis, superioribus papilla media inconspicua instructis, alaribus magnis, oblongis, vesiculosis, hyalinis vel luteis; *bracteae perichaetii* internae e basi vaginante raptim longe subulatae, superne argute serratae; *seta* usque ad 8 mm alta, tenuissima, rubra, apice scaberula; *theca* suberecta, minutissima, ovalis, atropurpurea; *operculum* e basi conica oblique subulatum.

BASILAN, Cumalarang, *Bur. Sci. 16268 Reillo.*

Species *Tr. Boschii* (Doz. et Molk.) affinis, sed foliorum forma setaque brevi jam dignoscenda.

SEMATOPHYLLUM (Mitt.) Jaeger

SEMATOPHYLLUM SUBULATUM (Hamp.) Jaeg.

LUZON, Laguna Province, Mount Maquiling, altitude 700 to 1,100 meters, *Bur. Sci. 17024, 17058, 17065, 17117, 17160, 17163 Robinson.*

SEMATOPHYLLUM ALTOPUNGENS (C. Müll.) Jaeg.

LUZON, Laguna Province, Mount Maquiling, *Bur. Sci. 17315 Robinson & Brown.*

SEMATOPHYLLUM HYALINUM (Reinw.) Jaeg.

LUZON, Laguna Province, Mount Maquiling, altitude 900 to 1,000 meters, *Bur. Sci. 17054, 17076, 17084 Robinson:* Pampanga Province, Mount Arayat, *Bur. Sci. 22449 Ramos.* CAMIGUIN DE MINDANAO, *Bur. Sci. 14903 Ramos.*

SEMATOPHYLLUM HERMAPHRODITUM (C. Müll.) Besch.

LUZON, Laguna Province, Mount Maquiling, altitude 1,000 meters, *Bur. Sci. 17098, 17116, 17319 Robinson:* Sorsogon Province, *Bur. Sci. 23746 p.p. Ramos.* CAMIGUIN DE MINDANAO, *Bur. Sci. 14901 Ramos.*

SEMATOPHYLLUM (CHAETOMITRIELLA) LUZONENSE Broth. sp. nov.

Dioicum; robustiusculum, caespitosum, caespitibus densis, viridibus vel lutescenti-viridibus, nitidis; *caulis* repens, dense ramosus, ramis usque ad 4 cm longis, dense ramulosis, ramis et ramulis dense foliosis, complanatulis, cuspidatis; *folia* patentia, cochleariformi-concava, ovato-ovalia, in acumen elongatum, piliforme contracta, marginibus erectis, integerrimis, enervia, cellulis incrassatis, conflatis, lumine angustissime lineari, flexuosulo, basilaribus infimis abbreviatis, aureis, alaribus quaternis, oblongo-vesiculosis, fusco-aureis, omnibus laevissimis; *bracteae perichaetii* erectae, foliis conformes, sed minores, acumine serrato, cellulis basilaribus laxioribus; *seta* 1.5 cm vel paulum ultra alta,

tenuissima, rubra, summo apice mamillis latis, humillimis obtecta; *theca* horizontalis, cylindrica, collo tuberculoso, atropurpurea; *operculum* e basi convexa longissime subulatum.

LUZON, Laguna Province, Mount Maquiling, on base of buttress-roots of living tree, altitude 600 meters, *Bur. Sci. 17010 Robinson.*

Species *S. pilifero* Broth. affinis, sed stratura duplo minore, foliorum forma nec non seta multo breviore optime diversa.

BRACHYTHECIACEAE

RHYNCHOSTEGIUM Bryol. eur.

RHYNCHOSTEGIUM VAGANS (Harv.) Jaeg.

LUZON, Ifugao Subprovince, Mount Polis, *Bur. Sci. 19932 McGregor.*
Area: Nepal, Sikkim, Java, Ceram and Ternate.

HYPNODENDRACEAE

HYPNODENDRON (C. Müll.) Lindberg

HYPNODENDRON FORMOSICUM Card

LUZON, Laguna Province, Mount Maquiling, on trees, altitude 750 to 1,000 meters, *Bur. Sci. 17094 Robinson.*

MNIODENDRON Lindberg

MNIODENDRON DIVARICATUM (Reinw. et Hornsch.) Lindb.

LUZON, Ifugao Subprovince, Mount Polis, *Bur. Sci. 20328 McGregor.* MINDANAO, Butuan Subprovince, *Weber 1304.*

MNIODENDRON FUSCOMUCRONATUM (C. Müll.) Broth.

LUZON, Bataan Province, *Bur. Sci. 22042 Medina.* BILIRAN, *Bur. Sci. 18458 McGregor.*

RHACOPILACEAE

RHACOPILUM Beauvois

RHACOPILUM SPECTABILE Reinw. et Hornsch.

LUZON, Benguet Subprovince, Pauai, *Baker 1326:* Ifugao Subprovince, Mount Polis, *Bur. Sci. 19929 McGregor:* Nueva Vizcaya Province, vicinity of Dupax, *Bur. Sci. 14849 McGregor.* BILIRAN, *Bur. Sci. 18457 McGregor.* CAMIGUIN DE MINDANAO, *Bur. Sci. 14888 Ramos.* PANAY, Iloilo Province, near Camp Larena, altitude 800 meters, *Robinson.*

POLYTRICHACEAE

POGONATUM Beauvois

POGONATUM ALBOMARGINATUM (C. Müll.) Jaeg.

LUZON, Abra Province, Mount Posuey, *Bur. Sci. 27087 Ramos.*

POGONATUM MICROSTOMUM R. Br.

LUZON, Benguet Subprovince, Pauai. *Baker 1338.*

POGONATUM SPURIO-CIRRATUM Broth.

LUZON, Laguna Province, Mount Banahao, *Merrill 7532, Bur. Sci. 19594 Ramos:* Benguet Subprovince, *Merrill 7831.*

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THE FUNGI CULTIVATED BY TERMITES IN THE VICINITY OF MANILA AND LOS BAÑOS

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TWO PLATES

It is well known that certain species of termites use their excreta for building combs upon which grow fungi that serve as food for the young and for the queen. Petch[1] has given a very extensive account of the fungi of the termite nests of Ceylon and, more recently, has written a general review of the literature on termite fungi. In the latter publication[2] he has shown that the same fungi occur on termite combs in very widely separated geographical regions.

Certain termites, which are very common in the vicinity of Manila, build nests that in many ways are similar to those described by Petch. These nests are of two types. One consists of a mound of earth which may be a meter or more in height and frequently in addition has cavities underground. The other is entirely underground. Within the nest are a large number of cavities connected by passages. In the center of the mounds (Plate III, fig. 1) there is usually a hard portion which contains the queen chamber and smaller cavities and passages connected with it. Outside of this region the cavities are larger and usually contain combs. Plate III, fig. 2, represents a section of the outer portion of a large nest.

The combs (Plate IV, fig. 1) are composed of small balls closely packed together and appear to be built from the excrement of the termites. In this, they agree with Petch's description. Their composition is quite different from the substratum of the "fungus gardens" of the Attii which according to Belt[3] are usually composed of fragments of leaves but also of flowers and fruit. Tanner[4] reports that the ants work these fragments with their mouth parts and then place them in position.

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[1] Petch, T., The fungi of certain Termite nests, *Ann. Bot. Gard. Peradeniya* 3 (1906) 185–270, *f. 3.*

[2] Petch, T., Termite Fungi: A résumé, *Ann. Bot. Gard. Peradeniya* 5 (1913) 303–341.

[3] Belt, Thomas, The Naturalist in Nicaragua (1874), ed. 2 (1888).

The termite combs, from Manila and Los Baños, (Plate III, fig. 2, and Plate IV, fig. 1) lie loosely on the floor of the larger cavities or chambers of the nest. They are brown, either flat or convexo-concave, about 2 centimeters thick and from a few to many centimeters in diameter. The passages in the combs are either rounded or elongated and run from the top to the bottom of the comb. They are frequently simple or a few may be connected together.

In the following discussion, the different fungi found on the termite combs in the vicinity of Manila and Los Baños, will be treated separately.

THE "CONIDIAL" SPHERE (AEGERITA DUTHEI BERK.)

The termite combs in the vicinity of Manila and Los Baños are impregnated with fungus hyphae and their surfaces are thickly dotted with rounded fungoid bodies on short stalks (Plate IV, fig. 1). These appear to be entirely similar to those described from Ceylon by Petch and are probably eaten by the termites, as what seem to be spores from these can be found inside the young termites.

Holtermann,[5] who studied the termites of India and Malaya, described these white, stalked, spherical bodies which occurred on the mycelium of the termite combs. Holtermann and Doflein[6] both found that these were eaten by the termites. Doflein suggests that these bodies form the food of all the larvae and the sexual individuals, while at a certain stage the soldiers and workers adopt another kind of food. The geographic distribution of these spheres is summarized by Petch[7] as follows:

> Holtermann regarded these spheres as identical in all the nests he examined, whether in Ceylon, Java, Singapore, or Borneo. It is, I think, clear from the description and figures of the Madagascar species that the latter is identical with that found in Ceylon; and from Berkeley's figures the Ceylon species is certainly the same as that found in India. Furthermore, Trägardh's description and figures of the fungus on the combs of *T. vulgaris* in the Sudan agree well with the Ceylon species. I have not been able to find any reference, in the literature at my disposal, to

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[4] Tanner, J. E., Oecodema cephalotes, the parasol or leaf-cutting ant, *Trinidad Field Nat. Club* 1 (1892) 68–69.

[5] Holtermann, C., Botanische Untersuchungen (1899) 411–420.

[6] Doflein, F., Die Pilzkulturen der Termiten, *Verhandl. Deutsch. Zool Gesellschaft* (1905) 140–149.

[7] Petch, T., Termite fungi: A résumé, *Ann. Bot. Gard. Peradeniya* 5 (1913) 303–341.

any similar fungus in termite nests in Australia or America, but in all the countries in which the fungus on the termite comb has been carefully examined the species is the same, as far as can be determined from a conidial form only.

In discussing the connection of these spheres with higher fungi occurring on termite combs Petch[8] says:

> It has been the aim of all mycologists who have studied the subject to establish a connection between the conidial fungus, (Aegerita Duthei) and one of the other termite fungi, but so far all these attempts have proved fruitless.

THE XYLARIA

When the combs from the vicinity of Manila or Los Baños were removed from the nests and placed in covered battery jars, a sterile form of what appeared to be a *Xylaria* always grew from them. These growths had a white core surrounded by a dense black layer which was tomentose with white to black hyphae. Branched specimens were rare except in cases where the developing fungus had come in contact with a solid object. The growths showed two very distinct types between which there were all degrees of intergradation. The largest (Plate IV, fig. 3) had a rudimentary stalk above which there was an oval shaped portion which usually tapered into a long whiplike extremity. The two largest specimens of this type were respectively 2.5 and 1 cm in diameter in the widest portion and 52 and 99 cm in length. The other extreme type (Plate IV, fig. 2) was a threadlike form averaging about 2 mm in diameter and 30 cm in length. The longest was 3 mm in its greatest diameter and 152 cm in length. Others were less than 1 cm long. The production of these two types seemed to be influenced by the age of the combs, the smaller type appearing in general on the oldest combs. The smallest specimens of the smaller type were produced under very dry conditions. A variety of these sterile forms is shown in Plate IV, fig. 3 while Plate IV, fig. 2 represents a cone bearing a large number of the smaller type.

The *Xylaria*-like growths do not seem to come from the conidial spheres on the combs as after the combs are removed from the nests the spheres turn brown and disappear in a few days. On the second day after the combs are placed in the battery jars they become covered by a very sparse growth of white mycelium, which comes out from the substance of the comb and not from the spherical bodies. On the third day feathery columns of white hyphae grow up, apparently, from the mycelium in the interior of the comb. As these columns increase in length the central portions become denser and in seven to ten days the separate columns have metamorphosed into the *Xylaria*-like structures. The outermost hyphae remain as a tomentose covering while the tips, especially in the larger type, are frequently composed of a mass of loose white hyphae. The sparse growth of hyphae which covered the comb undergoes a similar change and comes to have the appearance of a loose black net.

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[8] Petch, T., op. cit.

In two cases combs were placed in earth in brick flower pots, the combs being covered by a layer of earth about 2 cm deep. In the first case the pot was left uncovered. The structures produced were of the larger type and curled around the soil without appearing at the surface. In the other case the pot was placed under a battery jar. The *Xylaria*-like structures produced were mostly of an intermediate type but there were a few threadlike forms about 10 cm in length which were covered by a loose layer of conidiophores. The conidiophores grew out perpendicular to the axis of the fruit body and terminated in club-shaped four-lobed heads on which numerous rows of spores were borne. The entire head formed a somewhat flattened spherical structure. The spores were catenulate and from 4 to 5 μ in diameter. These spores are similar to the conidiospores ascribed to *Xylaria furcata* Fr.[9] Similar conidiophores were also produced on some sclerotia grown on agar. These sclerotia were obtained by taking a few hyphae from a developing sterile form and transferring them to agar in test tubes. In a few days these produced other sterile sclerotia from 6 to 10 cm in length and from 3 to 7 mm in diameter. By transferring hyphae from these to fresh tubes, before the sclerotia had turned black, other sclerotia were again produced. This process was repeated six times without any apparent diminution in the vigor of the growth. As some of these sclerotia dried out they became covered by a loose layer of conidiophores similar to those previously described. The entire structure of these fertile forms agrees quite well with the description which Petch gives of the Xylarias grown by him in pots except that his stromata were smaller, never being more than 1 cm in length.

In one jar simple conidiophores were produced on sclerotia grown on combs. These formed a dense covering around the apical part of the fruit bodies. The spores were oval and about 3 by 2 μ. Petch reports simple conidia with spores from 4 to 6 by 2 μ from *Xylaria nigripes.*

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[9] Petch, T., Termite fungi: A résumé, *Ann. Bot. Gard. Peradeniya* 5 (1913) 303–341.

The development and general appearance of the sterile *Xylaria*-like structures is very similar to Petch's description. The forms grown by him under bell jars showed a much greater tendency to branch than did the form under discussion; and were in general smaller, the longest mentioned by him having a length of only 14 cm. Petch, however, describes other forms which grew out of a deserted nest from combs 40 to 50 cm below the surface. These must have had a length comparable to that of those grown in Manila. The larger of the Manila types is, moreover, paralleled to some extent by sclerotia which he found in the same nest. These are described as black, irregular or fig-shaped, up to 8 cm in length and 3 cm in breadth. The lower left-hand figure in Plate IV, fig. 3 agrees very well with this description.

Petch [10] in writing of the Xylarias on termite combs says:

> To simplify matters, we may for the present adopt von Höhnel's view, that there are two species of *Xylaria* present.

Petch, however, apparently thinks that there is only one species as in discussing the number of species or termite combs, he says:

> Apparently there are two, but there are several facts which make it probable that these are forms of one species.

If there is only one species present, this is *Xylaria nigripes* Klotzsch. The ascigerous forms of *Xylaria nigripes* occurs at Los Baños on deserted termite nests, so that, although no connection has been traced between the *Xylaria* grown on termite cones and the ascigerous form of *Xylaria nigripes,* it is probable that this species is represented among the sterile forms. *Xylaria furcata* is a dichotomously branched species. The only dichotomously branched specimen in my cultures was an abortive one grown at Los Baños. This never turned black and did not develop further than the loose feathery stage. On the other hand, the catenulate spores, mentioned above, are similar to those ascribed to *Xylaria furcata.* The absence of branched specimens and the presence of these spores would seem to be another point of evidence indicating that *Xylaria furcata* is simply a form of *Xylaria nigripes.*

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[10] Petch, T., op. cit.

Petch[11] gives the following discussion of the distribution of *Xylaria nigripes:*

> Summing up, we find that *Sclerotum stipitatum* has been found in termite nests in India, Ceylon, Java, and Africa; *Xylaria nigripes* occurs in the same situation in Ceylon, Java, Madagascar, and probably Brazil; and *Xylaria furcata* in Ceylon and Java. *X. nigripes* has been recorded from other countries also, without any reference to its connection with termite nests. But in all such cases it is said to grow on the ground, not on wood. In Ceylon neither *X. nigripes* nor *X. furcata* are found except growing from termite nests.

The writer has not observed any *Xylaria*-like structures in termite nests, but Blanco[12] describes, under the name *Sclerotium subterraneum,* some sclerotia which came from a termite nest and which, judging by his description, had an appearance very similar to the larger form above considered. According to Petch[13] similar structures are found in India, Ceylon, Java, and Africa. Blanco's name is older than *Sclerotum stipitatum* Berk. and Curr.

The general appearance of the substance of the black network which grew over the combs in the vicinity of Manila and Los Baños, was very similar to the stromata of the *Xylaria,* while the structure of the individual cells of the two seemed to be identical. On some of these threadlike growths there appeared small, white, spherical sclerotia which in superficial appearance resembled very closely the spherical bodies on the combs. These sclerotia contained only one kind of conidia-like cells, but these, though smaller, have the same appearance as the conidia in the spherical bodies on the cones in the nests while the hyphae on which the two are borne appear to be entirely similar except for size. When these sclerotia were examined under a microscope they appeared to arise from the cells of the black threads and no other fungus hyphae were apparent. The hyphae of the sclerotia, moreover, had an appearance which except for size seemed to be identical with the hyphae which formed the stromata of the Xylarias. The presence of these sclerotia would suggest the possibility that the "conidial" spheres on the combs might grow from the hyphae of the *Xylaria.*

Petch observed small spherical sclerotia in his cultures. These, however, contained no conidia but in two cases produced Xylaria stromata.

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[11] Petch, T., op. cit.

[12] Blanco, M., Fl. Filip. ed. 2 (1845) 584.

[13] Petch, T., op. cit.

THE AGARIC

Petch[14] describes in considerable detail the agaric, *Collybia albuminosa* (Berk.) Petch, which grows from the actual combs in the termite nests. He[15] makes the following statements concerning its habitat:

> The agaric arises from the nest while it is still inhabited by the termites. It seldom appears on the actual termite hill, but usually among the grass round the base. At Peradeniya it is more frequently found growing from subterranean nests which have not yet attained the hill stage, and whose presence is indicated by a few small chimneys only.

Its geographic distribution is summarized by Petch[16] as follows:

> The occurrence of agarics in or around termite nests has been recorded from Ceylon, India, Singapore, Java, Borneo, and Brazil. The species in question is usually regarded as edible, and for that reason it has frequently been included in collections of tropical agarics; it is, for example, due to that fact that we have the records relating to termite nests in India. The names under which the agaric has been described differ in different countries, and even from the same country it has had several names bestowed upon it, but from a comparison of the descriptions, and the type specimens in some cases, it is quite certain that the species which develops from termite nests is the same in all the countries in which it has been found up to the present.

Although this fungus is very common on termite nests, it has not been grown from the combs removed from the nests.

The agaric occurs in two forms, identical so far as pilei are concerned, but differing in the character of the stalk. In one form the stalk is almost uniform in diameter throughout. In the other the lower part of the stalk is about two millimeters in diameter, but as it ascends to the soil it expands up to 1-2 centimeters in diameter.

While in Los Baños, my attention was called by Doctor E. B. Copeland to an agaric which appeared to be growing from the ground but which he had traced to termite combs in subterranean nests. This fungus showed two forms which Doctor Copeland has identified as the two forms of the agaric described by Petch from Ceylon. At Los Baños, as in Ceylon, this fungus appears to grow only from termite nests, and to be always connected with the combs.

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[14] Petch, T., The fungi of certain termite nests, *Ann. Bot. Gard. Peradeniya* 3 (1906) 185–270, *fig. 3.*

[15] Petch, T., Termite fungi: A résumé, *Ann. Bot. Gard. Peradeniya* 5 (1913) 303–341.

[16] Petch, T., op. cit.

ILLUSTRATIONS

PLATE III

FIG. 1. Vertical section through the center of a termite nest. The white strip of paper in the left of the picture is 50 centimeters in length. In the center of the nest is seen a compact structure with numerous passageways. This structure contains the queen cavity.

2. Vertical section through the peripheral part of a termite nest. The cones are seen very plainly in the cavities.

PLATE IV

FIG. 1. A small termite cone slightly reduced. The fungus bodies appear as white spots. That the cone is composed of a large number of round structures can be seen from the picture. These structures are the balls of termite excreta.

2. A termite cone producing a large number of small *Xylaria*-like structures.

3. A variety of *Xylaria*-like structures produced by termite cones. The scale represents 20 centimeters divided into centimeters.

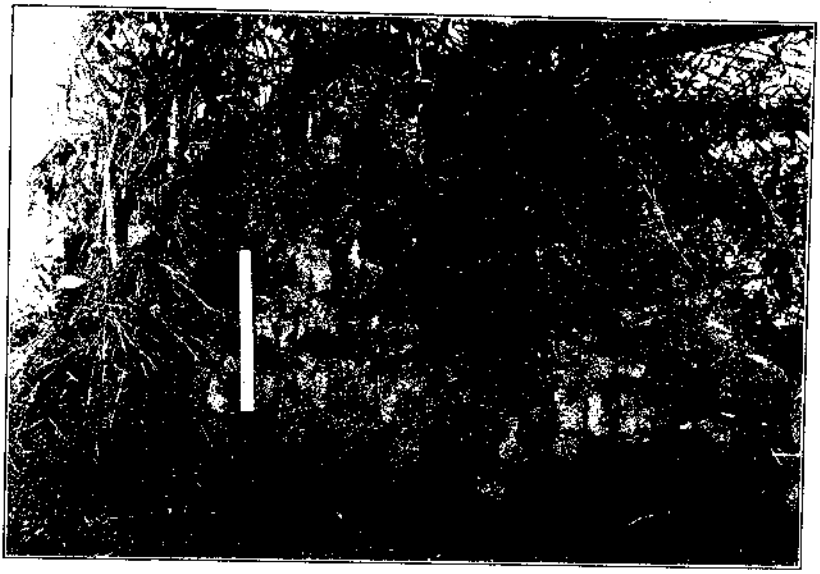


Fig. 1. Vertical section through the center of a termite nest.

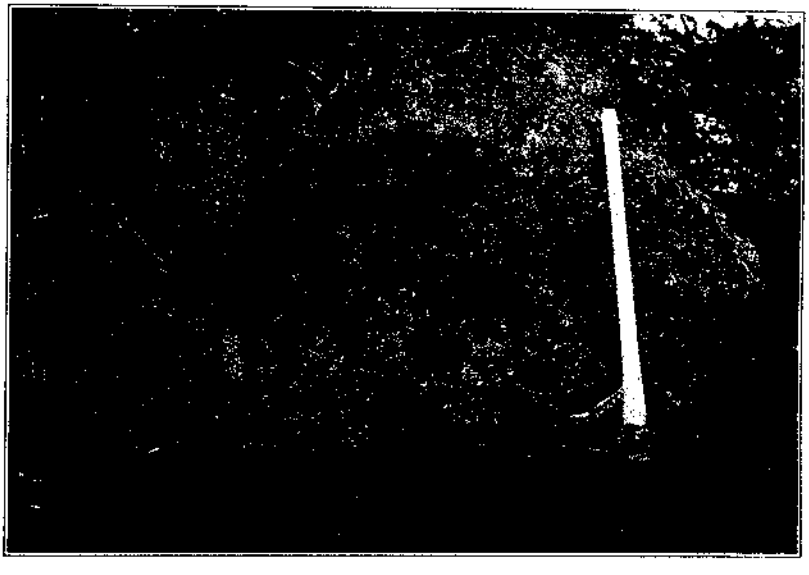
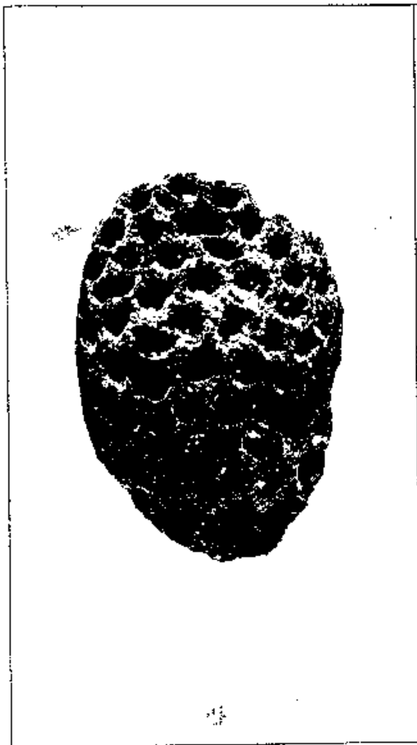
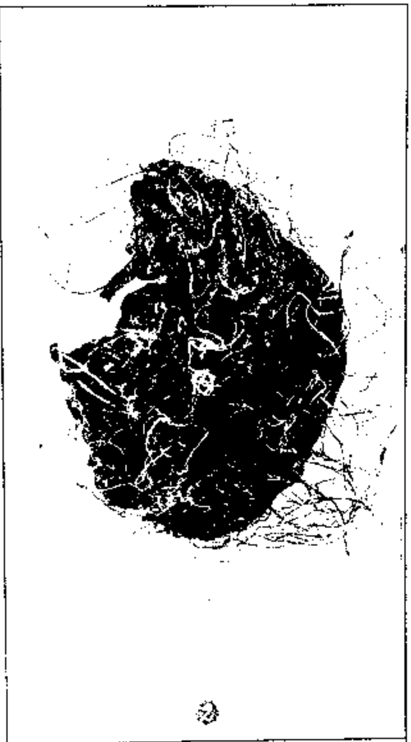


Fig. 2. Vertical section through the peripheral part of a termite nest.

PLATE III.





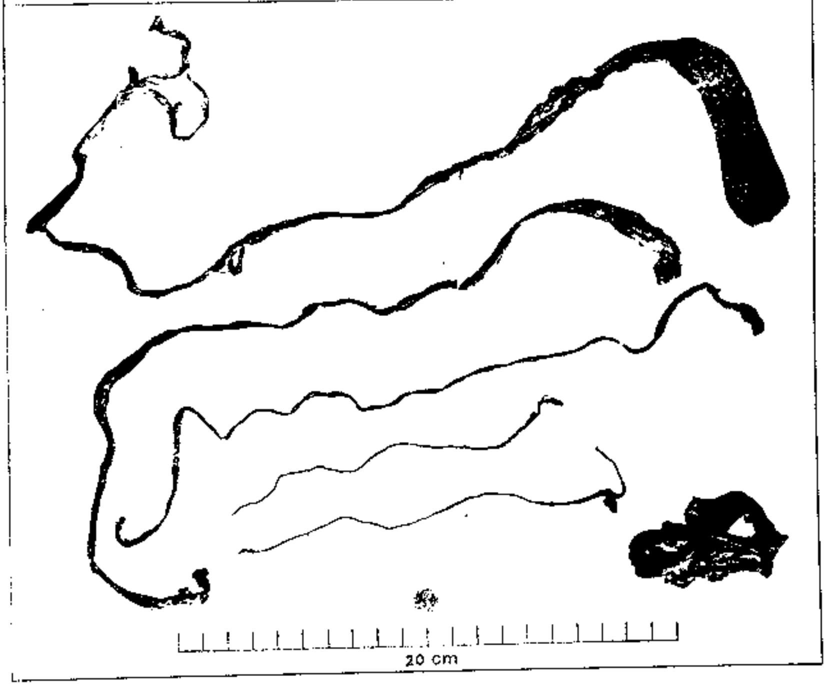


Fig. 1. A small termite cone slightly reduced. 2. A termite cone producing a large number of small Xylaria-like structures. 3. A variety of Xylaria-like structures produced by termite cone.

PLATE IV.

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FUNGI FROM BRITISH NORTH BORNEO

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The fungus flora of Borneo is at present but little known. In 1844 Léveillé[1] cited two species of *Exidia*, one of which is described as new, collected in Borneo by Korthals. Berkeley[2] gives a list of thirty-four fungi collected in Borneo; of these one is described as new. Nineteen are referred to the genus *Polyporus* and of the remainder all but three belong either to the *Polyporaceae* or *Agaricaceae*. In 1898 Massee[3] cited nine species of fungi from the east coast of British North Borneo, one of which is described as new. Three species belong to the *Agaricaceae* and the remainder are *Polyporaceae*. Hennings[4] describes a species of *Omphalia* from western Borneo near Bengkajang. Bresadola[5] gives the results of a study of a collection of fungi made by Winkler in 1908 in southeast Borneo. In this paper he cites twenty-one species all appertaining to the higher fungi, three of which are described as new. In 1912 Sydow[6] described five new species of lower fungi all collected in southeast Borneo by Winkler.

By far the most important paper dealing with Borneo fungi is that of Cesati[7] in which the fungi collected by Beccari during his travels in Borneo are listed and the new forms described. Unfortunately this publication is not available in Manila, but by a search through Saccardo's Sylloge Fungorum what is believed to be a fairly complete list of the fungi known from Borneo has been compiled. The total number of fungi reported from Borneo previous to the present paper is two hundred ninety-six; of these about thirty are *Agaricaceae*, eighty-three *Polyporaceae*, sixteen *Thelephoraceae*, three *Clavariaceae*, and one *Hydnaceae*, making a total of one hundred thirty-two to be referred to the higher fungi. Of the remainder, forty-three species belong to the *Xylariaceae* and about thirteen to the

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[1] Ann. Sci. Nat. Bot. III 2 (1844) 167–221.

[2] Hooker Journ. Bot. Kew Miscel. 4 (1852) 161–164.

[3] Kew Bulletin (1898) 119–120.

[4] Hedwigia 32 (1893) 63, *t. 7, f. 3*.

[5] Ann. Myc. 9 (1911) 549–553.

[6] Ann. Myc. 10 (1912) 77–85.

[7] Atti Accad. Sci. Napoli 8 (1878) 1–28, *t. 1–4*

Hypocreaceae. A few species each of *Phallaceae, Lycoperdaceae, Nidulariaceae, Sphaeriaceae,* and *Pezizaceae* are reported. Other groups are represented in the list by only one or two species. Four *Laboulbeniaceae* have been reported from the island. Up to the present time only one species of *Meliola* had been recorded from Borneo.

In examining the data in reference to the number of fungi reported from Borneo it is to be noted that most of the species belong to groups in which the plants are relatively large and conspicuous. Comparatively few representatives of the smaller leaf parasites appear in the list. In listing the fungi reported from Borneo, I have made no attempt to adjust the synonomy and so the actual number of distinct forms is probably considerably less than the figures as given above would indicate. The extent of our knowledge of Bornean fungi appears to be at least no greater than that possessed of Philippine fungi previous to 1906 when Ricker's[8] compilation showed less than two hundred species to be known from the Archipelago. While no exact data is available at the present time, it is probable that the known Philippine fungi number between 2,000 and 2,500 species. In fact it seems likely that our knowledge of Bornean fungi at the present time is comparatively less than was our knowledge of the Philippine forms in 1906, since in 1906 a proportionately far larger number of inconspicuous forms of Philippine fungi were known than is the case regarding the smaller forms in Borneo.

The present paper gives the results of a study of a small collection of fungi secured by the writer during a recent visit to British North Borneo. The fungi were collected incidental to other work and were mostly secured in the lowlands along the coast as no time was available for excursions into the forests of the interior. As is to be expected a large proportion of the specimens secured are referable to well known and widely distributed species. Five apparently new species are described and a number previously unknown from Borneo are recorded.

CENANGIACEAE

TRYBLIDIELLA Saccardo

TRYBLIDIELLA MINDANAENSIS P. Henn. in Philip. Journ. Sci. 3 (1908) Bot. 53.

BRITISH NORTH BORNEO, Membakut, *Yates 116*, October 9, 1917, on dead branches of *Hevea brasiliensis;* Tenom, *Yates 87*, October, 1917, on the same host.

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[8] Philip. Journ. Sci. 1 (1906) Suppl. 277–294.

This is one of the commonest species of the lower fungi in the Philippines and apparently is also abundant in Borneo. It is a saprophyte and occurs in all sorts of dead wood. It has also been collected in the Philippines on dead branches of *Hevea brasiliensis*.

PERISPORIACEAE

MELIOLA Fries

MELIOLA PTEROCARPIAE sp. nov.

Maculis epiphyllis, subpelliculosis, atris, orbicularibus vel suborbicularibus, 2 ad 6 mm diametro, vel confluentibus et magnam parten folium occupante, mycelio tenuissimo, ex hyphis parce ramosis brunneis 6 ad 8 μ crassis composito; ramis plerumque oppositis; hyphopodiis capitatis numerosis, alternantibus, cellula superiore ovata, 11 ad 13 X 19 ad 12 μ, cellula inferiore 5 μ longa; hyphopodiis mucronatis paucissimis, ampulliformibus, usque ad 18 μ longis; setis mycelicis validis, rectis, erectis, atris, opacis, simplicibus, acutis, 200 μ longis, 10 ad 12 μ crassis; peritheceis numerosis, globosis, atris, opacis, 125 ad 140 μ diametro; ascis ovatis, bisporis, mox diffluentibus; sporidiis cylindraceis, utrinque late rotundatis, 4-septatis, ad septa constrictis, brunneis, 38 ad 40 X 12 ad 15 μ.

BRITISH NORTH BORNEO, Tenom, *Yates 102*, October 17, 1917, on leaves of *Pterocarpus indicus*.

Parasitized by *Spegazzinia* and associated with *Phaeodothiopsis pterocarpae* Yates.

MELIOLA OTOPHORAE sp. nov.

Maculas epiphyllas, atras, orbiculares vel suborbiculares, 2 ad 5 mm diametro; mycelio abundante, ex hyphis rectis vel tortuosis brunneis 7 ad 8 μ crassis composito; ramosis, ramis plerumque alternantibus; hyphopodiis capitatis numerosis, cellula superiore oblonga vel subinde lobata, 10 ad 12 μ longa, 6 ad 10 μ lata, cellula inferiore 5 ad 6 μ longa; hyphopodiis mucronatis paucissimis, ampulliformibus, usque ad 15 μ longis, setis mycelicis erectis, rectis, obscure brunneis, 350 ad 450 μ longis, 7 ad 8 μ crassis, acutis; peritheceis numerosis, globosis, atris, opacis, 150 ad 200 μ diametro; ascis ovoideis, 30 ad 35 X 18 ad 20 μ, bisporis; sporidiis 4-septatis, ad septa constrictis, cylindraceis, utrinque obtusis, brunneis, 30 ad 32 μ longis, 8 ad 12 μ latis.

BRITISH NORTH BORNEO, Sapong, *Yates 107*, October 16, 1917, on the leaves of *Otophora fructicosa*.

MELIOLA JASMINICOLA P. Henn. in Hedwigia 34 (1895) 11.

BRITISH NORTH BORNEO, Bangawan, *Yates 94*, October 10, 1917, on *Jasminium sambac*.

Hennings' description of material from Tonkin states that the perithecia are 240 to 300 μ in diameter, in the Bornean material they are about 150 μ in diameter; the spores are given as 30 to 36 × 10 to 15 μ and in our specimens they are 40 to 45 × 15 to 18 μ. I have referred this material to *Meliola jasminicola* because comparison with material in the herbarium of the Bureau of Science (*Merrill 7469*) of a *Meliola* on *Jasminium sambac* determined by Sydow as *M. jasminicola* shows the same variation as do the Bornean specimens.

MELIOLA MANGIFERA Earle in Bull. New York Bot. Gard. 9 (1904) 307.

BRITISH NORTH BORNEO, Membakut, *Yates 111*, October 9, 1917, on leaves of *Mangifera indica*.

Our specimens differ in certain details from the description, but in general seem to agree closely enough to be placed here. In our material the spots are mostly on the upper surface of the leaves but occur also upon the lower surface. The setae are comparatively few and all of one sort; they are 500 to 700 μ long and the tips are acute. The species was originally described from Jamaica and has also been collected in the Philippines, Porto Rico, and India.

CAPNODIACEAE

AITHALODERMA Sydow

AITHALODERMA CLAVATISPORUM Syd. in Ann. Myc. 11 (1913) 257, *f. 3*.

BRITISH NORTH BORNEO, Sandakan, *Yates 83*, October 26, 1917, on leaves of *Acrostichum aureum; Yates 83a*, on *Mallotus polyanthus*.

This species was first described on *Voacanga globosa* from the Philippines and has since been collected on *Psidium guajava, Ixora coccinea, Antidesma bunius* and *Sandoricum indicum*. The Borneo specimens appear to be referable here though the mycelium is much less dense than in the Philippine material. The entire upper leaf surface is covered by a black coating which is readily removed as a pellicle.

CAPNODIUM Montagne

CAPNODIUM sp.

Mycelium crustaceous, widely effused and entirely covering the upper surface of the leaf, black; hyphae brown, septate, branched, articulations varying, but mostly 5 to 10 μ long, constricted at the septa, 5 to 8 μ in diameter, lighter brown filamentous hyphae are also present; pycnidia cylindric, enlarged at the base, 500 to 700 μ long; perithecia numerous, 100 μ in diameter; no ascospores found.

BRITISH NORTH BORNEO, Membakut, *Yates 99*, October 9, 1917, on leaves of *Annona*.

Patouillard, in Bull. Soc. Myc. Fr. 20 (1904) 135, has described a species of *Capnodium* (*C. anonae* Pat.) on *Annona squamosa* from Polynesia, but it appears to differ very considerably from our species. *Capnodium anonae* has been reported on leaves of *Ficus* and *Agave* from India by Sydow and Butler in Ann. Myc. 9 (1911) 384.

HYPOCREACEAE

MEGALONECTRIA Spegazzini

MEGALONECTRIA PSEUDOTRICHIA (Schw.) Speg. in Anal. Soc. Cienc. Argent. 12 (1881) 217.

Sphaerostilbe pseudotrichia B. & Br. in Journ. Linn. Soc. Bot. 14 (1875) 114.

Nectria pseudotrichia B. & C. in Journ. Acad. Phila. II 2 (1835) 289.

Sphaeria pseudotrichia Schw. in Berk. & Curt. Journ. Acad. Phila. II 2 (1853) 289 (as synonym).

BRITISH NORTH BORNEO, Tenom, *Yates 86*, October 16, 1917, on dead branches of *Hevea brasiliensis*.

This is very abundant on dead branches lying on the ground and is often associated with *Diplodia cacaoicola*.

HYPOCREA Fries

HYPOCREA BORNEENSIS sp. nov.

Stromatibus gregariis, sessilibus, convexo-pulvinatis, 3 ad 6 mm diametro, extus brunneis, intus pallide brunneis; peritheceis globosis, immersis, ostiolis punctiformibus, brevis, ascis cylindraceis, aparaphysatis, 70 ad 80 X 5 ad 6 μ, 8-sporis (simulate 16-sporis); sporidiis monostichis e duabus cellulis aequalibus compositis, mox decedentibus, cellulis singulis globosis, hyalinis, 4 ad 5 μ diametro.

BRITISH NORTH BORNEO, Membakut, *Yates 100*, October 9, 1917, on decaying log of *Hevea brasiliensis*.

PHYLLACHORACEAE

PHAEODOTHIOPSIS Theissen et Sydow

PHAEODOTHIOPSIS PTEROCARPI sp. nov.

Stromatibus epiphyllis, numerosis ca. 0.5 ad 1.5 mm diametro, dispersis, carbonaceis, hemisphaerico-pulvinatis, laevibus, atris, in maculis fuscidulis, 2 ad 3 mm diametro dispositis; loculis ca. 6 ad 12, 80 ad 120 μ diametro, globosis; ascis cylindraceis, 50 ad 60 μ longis, 10 μ latis, 8-sporis, paraphysatis; sporidiis distichis, oblongis, utrinque rotundatis, brunneis, ad basim 1-septatis, constrictis, cellula superiore 10 X 12.5 μ, inferiore 3 ad 4 μ longa et 3 μ lata.

BRITISH NORTH BORNEO, Tenom, *Yates 104*, October 17, 1917, on leaves of *Pterocarpus indicus*.

This species is very abundant on the leaves of *Pterocarpus*, associated with *Meliola pterocarpiae* Yates. The 2-celled brown spores readily distinguish it from the other *Phyllachoraceae* reported upon this host. Conidia are borne on the younger stromata. They are subglobose or somewhat irregular in shape, brown and about 10 to 12 μ diam.

TRABUTIA Saccardo et Roumeguére

TRABUTIA VERNICOSA Theiss. et Syd. in Ann. Myc. **13** (1915) 353.

BRITISH NORTH BORNEO, Bangawan, *Yates 92*, October 10, 1917, on leaves of *Ficus* sp.

This specimen is apparently to be referred to this species which has previously been collected only in Mindoro, Philippines. It appears to be very abundant on *Ficus* in Borneo.

MYCOSPHAERELLACEAE

MYCOSPHAERELLA Johanson

MYCOSPHAERELLA ALOCASIAE Syd. in Philip. Journ. Sci. **8** (1913) Bot. 195.

BRITISH NORTH BORNEO, Tenom, *Yates 84*, October 16, 1917, on leaves of *Alocasia macrorrhiza.*

Unfortunately the specimens are rather immature and the spores are not fully developed, but otherwise the material agrees well with *Mycosphaerella alocasiae* which is very common on *Alocasia* and related plants.

VALSACEAE

EUTYPA Tulasne

EUTYPA BAMBUSINA Penz et Sacc. in Malpighia **11** (1897) 501; Ic. Fung. Java (1904) *t. 23, f 1.*

BRITISH NORTH BORNEO, Papar, *Yates 110*, October 14, 1917, on dead bamboo.

This was first described from Java, and is one of the most abundant species in the Philippines. It appears to occur only upon dead bamboo.

XYLARIACEAE

DALDINIA de Notaris et Cesati

DALDINIA CONCENTRICA (Bolt.) Ces. et De Not. in Comm. Critt. Ital. **1** (1863) 198.

Sphaeria concentrica Bolt. Hist. Fung. Halifax **3** (1791) 180 *t. 1.*

BRITISH NORTH BORNEO, Membakut, *Yates 69*, October 9, 1917, on dead log of *Hevea brasiliensis.*

A cosmopolitan species very common on many kinds of dead wood in the Philippines and one of the few species collected by me that has previously been reported from Borneo.

KRETZSCHMARIA Fries

KRETZSCHMARIA ? PECHUELII P. Henn. in Engl. Bot. Jahrb. 14 (1891) 365, *t. 6, f. 10.*

BRITISH NORTH BORNEO, Tenom, *Yates 103*, October 17, on a dead and half decayed log of *Hevea brasiliensis.*

Kretzschmaria pechuelii was described by Hennings from material collected on dead stumps in Africa. In our material the fungus is about 15 millimeters high, the sterile portion branching, the branches contiguous and the more or less spherical fertile portions at the end of each branch also contiguous and forming a crust. Our material appears to be somewhat larger and more robust than the form described by Hennings. The asci were not seen but the spores agree very well with Hennings' description. This may be a distinct species but in the absence of material of *K. pechuelii* for comparison I have referred it to that species.

USTULINA Tulasne

USTULINA ZONATA (Lév.) Sacc. in Syll. Fung. 1 (1882) 352.

Sphaeria zonata Lév. in Ann. Sci. Nat. III 3 (1845) 48.

BRITISH NORTH BORNEO, Membakut, *Yates 112,* October 9, 1917, on the base of trunks of living *Hevea brasiliensis.*

This fungus was first described from material obtained on a palm in Java. It causes a serious disease of tea in Ceylon and is now known to cause a rather important disease of *Hevea brasiliensis* in Malaya. It has also been reported on *Hevea brasiliensis* and a number of other hosts in Ceylon.

THELEPHORACEAE

CORTICIUM Persoon

CORTICIUM SALMONICOLOR B. et Br. in Journ. Linn. Soc. Bot. 14 (1875) 71.

Necator decretus Mass. in Kew Bull. (1898) 119.

Corticium javanicum Zimmerman in Centralbl. Bakter. 7 (1901) 103.

Corticium zimmermanni Sacc. et Syd. Syll. Fung. 16 (1902) 117 (Nomen); Syll. Fung. 17 (1905) 169.

BRITISH NORTH BORNEO, Membakut, *Yates 114,* October 9, 1917, on living branches of *Hevea brasiliensis; Yates 115,* on branches of *Annona.*

This fungus was first described from Ceylon material about 1875 and apparently did not attract attention again until about 1897 when it appeared on coffee in Malaya. Specimens sent to Kew were described by Massee as a new genus and species of *fungi imperfecti* which he named *Necator decretus* Massee. In 1901 Zimmermann reported the fungus on coffee, tea, *Bixa orellana* and *Erythroxylon coca* in Java and connected *Necator decretus* Massee with the perfect stage which he described as *Corticium javanicum* Zimm. It was first reported from Borneo by Ridley in 1904 on *Hevea* sent from Sandakan. It is now known to occur practically throughout the tropical regions of the orient and a recent report indicates its presence in Porto Rico. It causes a very serious disease of rubber in Malaya and Borneo and of tea in Ceylon. In the Philippines it causes a rather serious disease of *Citrus.*

POLYPORACEAE

DAEDALEA Persoon

DAEDALEA IMPONENS Ces. in Atti Accad. Sci. Napoli 8 (1878) 7.

Funalia philippinensis Murr. in Bull. Torrey Bot. Club. 34 (1907) 469.

BRITISH NORTH BORNEO, Tenom, *Yates 105,* October 17, 1917, on dead partly decayed logs.

While the specimens differ in some respects from Cesati's description, as given in the Sylloge Fungorum, they agree fairly well with specimens in the Bureau of Science herbarium so named by Bresadola. When fresh the margin of the pileus was lavender in color, soon fading however to brown.

SPHAERIOIDACEAE

PHYLLOSTICTA Persoon

PHYLLOSTICTA HEVEAE Zimm. in Bull. Inst. Bot. Buitenz. 10 (1901) 21.

BRITISH NORTH BORNEO, Membakut, *Yates 113*, October 9, 1917, on leaves of *Hevea brasiliensis*.

This specimen is referred here though it differs in some respects from Zimmerman's description. The spores are about 8 x 3.5 to 4 μ and the ends are obtuse.

PHYLLOSTICTA MELOCHIAE sp. nov.

Maculis amphigenis, orbicularibus, 2 ad 4 mm diametro; albescentibus, linea fusco-purpurea cinctis; pycnidiis epiphyllis sparsis, immersis, minutissimis, atris, 45 ad 60 μ diametro, poro vix conspicuo, contextu subopaco, irregulariter parenchymatico; sporûlis paucis, subglobosis, hyalinis, 5 ad 6 X 4 ad 4.5 μ diametro, intus granulosus.

BRITISH NORTH BORNEO, Tenom, *Yates 109*, October 16, 1917, on *Melochia* leaves.

The spots are small and irregularly scattered over the leaf. The affected tissue finally drops out leaving holes in the leaf.

DEMATIACEAE

CERCOSPORA Fresenius

CERCOSPORA MANGIFERAE Koord. Bot. Unters. Java Pilz. (1907) 236, *f. 47*.

BRITISH NORTH BORNEO, Bangawan, *Yates 93*, October 10, 1917, on leaves of *Mangifera indica*.

This species was first described from Java and is a common fungus on this host in the Philippines. The leaf spot produced by the fungus apparently causes very little injury to the tree.

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SOME MICROTECHNICAL METHODS AND DEVICES

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FIVE TEXT FIGURES

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During several years of teaching botany and pharmacognosy, and collecting and preparing material for a study of the *Volvocaceae* of the vicinity of Manila, it has been found expedient to employ modifications of the methods laid down in the various laboratory handbooks. For the most part these modifications, made to meet requirements of the work in hand and local conditions, have originated in suggestions obtained during many years from many sources which it would now be difficult, if not impossible, to trace. The methods and devices here presented have served useful purposes for the writer and his students in the past and are here published that they may be available for others in the future.

OCULAR MICROMETERS USED AS STAGE MICROMETERS

In an instruction laboratory in which each compound microscope is furnished with a linear and a square-ruled micrometer disk, each of these scales may be used as a stage micrometer for determining the value of the intervals of the other used as an ocular micrometer. The disk to serve as the stage micrometer is easily affixed to a clean slide with a capillary film of water. By this means I am enabled to give simultaneously to all the students of a class exercises in the determination of the micrometer scale values without the expense of supplying a stage micrometer for each student.

THE SQUARE-RULED MICROMETER USED AS A POSITION INDICATOR

For the purpose of referring to specific parts of the microscope field in the discussion of objects in view under the compound microscope, the square-ruled ocular micrometer scale is in some ways superior to the field pointer. When so using the scale I assign numbers to the transverse rows of squares and letters to the vertical rows so that each small square in the scale may be specifically indicated by a number with a letter. The Zeiss scales that I use are not marked with numbers. If the scales were to be so marked I would prefer that the transverse rows be numbered and the vertical rows lettered. The obvious advantage of using this accessory instead of a field pointer is that many different parts of the field can be indicated without readjustment of the apparatus.

THE SQUARE-RULED MICROMETER FOR DRAWING TO SCALE

For use in drawing to scale from the compound microscope all students in my classes in botany and pharmacognosy since 1911 have been supplied with square-ruled ocular micrometers. I have found it convenient to use for the drawing a thin [1] semitransparent paper of suitable texture, and to place under it a paper scale ruled into squares corresponding to those of the ocular scale. Using a Zeiss No. 3 huygenian micrometer ocular containing a micrometer disk with a 5 mm square ruled at 0.5 mm intervals each way and a paper scale 90 mm square ruled at 9 mm intervals, magnifications of 120 and 500 diameters are obtained with the Zeiss achromatic objectives A and D, respectively. As paper scales for any desired magnification can be easily provided, this method affords unrestricted choice within a greater range of available magnifications than can be had with a camera lucida. The dimming of the microscope image and the complication of light adjustments attendant on the use of the Abbe camera lucida are avoided by the use of the square micrometer as an aid in drawing. And the expense of equipment and deterioration is comparatively insignificant.

CAPILLARY GLASS RODS FOR COVER-GLASS SUPPORTS

In making Venetian-turpentine mounts of delicate objects as variable in size as the *Volvocaceae* it is desirable to have cover-glass supports of greater range of thickness than is afforded by the use of fragments of cover glasses. Pieces of capillary glass rods serve this purpose well. Ordinary glass rods are heated to softness in a flame and drawn out to suitable thinness. As they then taper more or less it is well to pass the drawn rods through the jaws of a cover-glass tester, of the type manufactured by Zeiss, and break them at points corresponding to the limitations selected for a series of grades according to size. I keep the graded pieces of rod in marked watch glasses or vials and break them into short lengths for use. Four short pieces are distributed on the slide in the Venetian turpentine before the cover is added. A light clip is used to make the cover settle down on the rods. One advantage of using rods instead of bits of cover-glass is that the rods, being approximately cylindrical, may have their thickness determined, at any time after being mounted, by the use of the ocular micrometer.

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[1] The use of a translucent drawing table illuminated from below, with the square-ruled scale on thin paper or on the glass of the table, would make it possible to use thicker drawing paper.

AUTOGRAPHIC RECORDS ON MICROGRAPHIC NEGATIVES

These may be made by a device so simple that it seems probable that it has already been employed. I have used it for numbering negatives, but it is suitable for any autographic record, which it may be desirable to make on a micrographic or other photographic plate in the laboratory, and might be adapted to service with a plate camera in the field. The data are written with black drawing ink on a piece or pieces of transparent celluloid. Kodoid plates furnished the celluloid used by me. For serial numbers the labels were prepared in advance. After all adjustments have been made preliminary to insertion of the plateholder, the celluloid label is attached by bits of adhesive tape to the metallic diaphragm close to the focal plane of the camera, in a part of the field selected for the purpose. Its location may be verified by making another inspection of the image on the ground glass before inserting the plate holder for the exposure.

A METHOD OF RECORDING MAGNIFICATION ON MICROGRAPHIC NEGATIVES

It is a simple matter to photograph the image of a slide-micrometer scale on a negative beside the image of any microscopic object so that the scale and object appear side by side on the photographic positive and any reproduction. The advantage of this method of indicating the scale of magnification over that in which the scale is drawn on the finished print is obvious.

For this purpose one side of the circular camera field is blocked out by a screen attached to the metallic diaphragm, which in every good micrographic camera is close to the ground glass and plate. The necessary adjustments are made to bring the image of the object near the shadow of the screen, and the exposure is made. Then the plate holder is removed; a second screen is fixed to the diaphragm to block out the remainder of the field, its edge just touching the first screen, after which the first one is removed. The micrometer slide is then substituted for the object slide on the stage of the microscope and adjusted to throw its image on the unexposed portion of the plate. A second exposure of the plate is then made of the same duration as the first.

Pieces of black paper with straight edges serve for screens and are easily fixed in place by pieces of adhesive tape. Sheets of black metal would do as well or better, and clips might be provided for holding them in place. Or a pair of diaphragms with complementary openings might be employed in place of the single diaphragm with its circular opening. However, the use of adjustable screens has the advantage of permitting variation of the position of the scale to suit the size of the object image.

To facilitate the adjustment of the micrometer slide there may be gummed to its upper side two strips of black paper; one across the slide to block off all the space beyond one end of the scale, and the other lengthwise to block off as much of the scale lines as is superfluous, leaving exposed only a short portion of each of the lines which mark the smaller divisions. The slide thus blocked may be very quickly brought into position on the microscope stage and afterward brought into focus.

CONCENTRATION OF GLYCERIN HASTENED BY THE VACUUM PUMP

In his most admirable presentation of the glycerin and Venetian-turpentine methods of making microscopical preparations, Chamberlain[2] directs that the material, properly prepared, be put in 10 per cent glycerin (1 part glycerin and 9 parts water) and the water allowed "to evaporate gradually in a place as free from dust as possible." He specifically states that:

> It is not necessary to use an exsiccator. Merely put the glycerin into shallow dishes, and leave it exposed to the air, but protected from dust. If the material is in Petri dishes or other dishes with a large surface, 3 or 4 days will be sufficient. This process should not be hastened by warming.

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[2] Chamberlain, Chas. J., Methods in Plant Histology, 3d revised edition, Chicago (1915) 93 and 98.

Working with *Volvocaceae* and other algae at Manila, I have not found the above specified procedure satisfactory. It was sometimes successful, but often the evaporation of the water from the glycerin was so slow that fungus mycelia developed to the ruination of the specimens which were exposed to the air in shallow dishes, but protected from dust. And, usually, glycerin which has been concentrated becomes greatly diluted by absorption of atmospheric moisture on extended exposure to the air. I have secured satisfactory evaporation of the water from the glycerin for small quantities of material by the use of the desiccator, and for larger quantities by the use of the vacuum pump. But to provide for the suppression of fungous growth during early stages of evaporation, and on holidays when the vacuum pump, located in the power house, is not in operation, thymol was added to the dilute glycerin. The glycerin solution was prepared by dissolving 0.9 gm of thymol in 9 cc of 95 per cent alcohol, adding the solution to 900 cc of distilled water and shaking, and finally adding 100 cc of glycerin and shaking again. While the thymol prevents fungous growth, it cannot be relied on to serve indefinitely in open dishes, for it seems to escape in the course of time. And pieces of thymol, to be of service, would need to be fastened below the surface of the liquid. In using the desiccator for the evaporation, it is preferable to have the material in vials with narrow mouths, or if it be in wide shallow dishes, to keep the dishes nearly covered to insure that the evaporation and concentration be not too rapid.

For concentrating glycerin containing from 2.5 to 25 cc of *Volvocaceae* wide-mouthed bottles of 250 cc capacity are used. Each bottle is provided with a rubber stopper with two holes. In one hole is placed a bent glass exit tube which does not extend below the stopper. In the other hole is placed a glass tube of which the lower end is drawn to capillary fineness. It is broken off until, by trial, a suitable nozzle is obtained. It does not extend below the bottom of the stopper. The upper end is filled with a plug of cotton just dense enough to serve as a dust arrestor. The specimens in dilute glycerin are placed in the bottle, which is filled with the solution up to the shoulder. The stopper with its tubes is inserted in the bottle, and the outlet tube is connected with the vacuum apparatus. In the system used the pressure varies, but averages about one-fifth of an atmosphere. When the vacuum cock is open the air jet from the capillary nozzle should produce a depression in the surface of the liquid without undue stirring or agitation. Several days are required for concentration of the glycerin. Too rapid concentration causes shrinkage of the specimens. Passing the air admitted to the bottle through calcium chloride tubes and a sulphuric acid gas drier does not materially accelerate the evaporation.

When smaller quantities than 2.5 cc of material are to be treated, the specimens in dilute glycerin are placed in a cylindrical vial about 23 mm wide and 80 mm deep, which is filled to a depth of about 70 mm. This vial is then placed in the larger bottle so as to stand under the air jet. When used in this way the larger bottles are provided with a floor of paraffin, which is melted and then cooled while the bottle stands on a level support, to give it a flat, level surface.

The use of an aspirator or aspirator pump for providing the air blast is yet to be tried.

A METHOD FOR MAKING SEALED GLYCERIN MOUNTS

Sealing mounts in concentrated or dilute glycerin presents a difficulty that does not occur in the use of aqueous media, which on evaporation leave the cover and slide surfaces dry; namely, the impossibility of securing contact of the cementing medium with glass surfaces which have become coated with a film of the nonvolatile glycerin. And, further, owing to its hygroscopic property, the glycerin takes up atmospheric moisture through the least crevice, expanding, and exuding in damp weather, and evaporates, contracting, and drawing air under the cover, until, after the seasonal changes of several years, slides defectively sealed are likely to become completely dry. This difficulty can be obviated by using a cement which is readily freed from a glycerin coat and providing contact of the cement with the glass surfaces before the glycerin is applied.

I have made mounts of the larger *Volvocaceae*, which require considerable space between slide and cover, and these are in good condition after three years. The cement used is an alcoholic solution of shellac. It is applied with a brush. The method will now be described in detail.

Orange flake shellac is prepared by covering it with 95 per cent alcohol and allowing it to stand for several days. If the resulting solution be too thin it is allowed to evaporate partially; if too thick more alcohol is added. A camel's hair brush for applying the shellac is inserted in a perforated rubber stopper of a bottle of 95 per cent alcohol, in which it is kept when not in use.

A clean slide is placed on a self-centering turntable, with care that if it be slightly curved it shall rest on its ends and not on its middle. With the table rotating slowly a ring of shellac is applied to the slide. This ring is made of such width that there are several millimeters of ring both within and without the area of the circular cover glass to be used. The slide is placed in a desiccator for the shellac to harden, after which additional rings are added in the same manner until the ring has been built up to the required thickness. Then, the ring being dried to a suitable consistency, the slide is placed on the turntable, rotated, preferably by means of a motor, and the inner edge of the ring is trimmed away with a sharp instrument. This leaves the inner side of the ring nearly perpendicular, doing away with the sloping beach on which specimens would be liable to get stranded and be crushed by the cover glass. It is preferable that the thickest part of the ring be at or near its inner edge, and therefore well within the periphery of the cover. A clean, circular cover glass is then laid on the ring and, if the consistency of the ring be just right, a slight pressure on its center with a clean needle will cause it to stick sufficiently to permit the application of a thin ring of shellac to the cover. This ring is made with its inner diameter the same as that of the slide ring and extends just to the outer edge of the cover. The cover is then removed from the slide and placed in a desiccator for the shellac to harden.

The specimens in glycerin are placed on the slide with sufficient liquid to fill the space within the ring. The cover is placed on the liquid with its ring lowermost and pressed gently upon the slide ring. For continued pressure cylindrical metal weights, a little smaller than the cover, are used. Superfluous glycerin is removed from the upper surface of the slide ring with the moistened end of a strip of filter paper. Then the slide is placed on the turntable and shellac is applied so as to occupy all space between the two shellac rings. Finally the slide is again placed in a desiccator for hardening the shellac.

Failures will be indicated, after a time, according to the condition of the atmosphere to which the mounts are exposed. In moist atmosphere there will be exudation of the liquid, and in dry atmosphere bubbles will appear and grow.

It is not desirable to use glass supports for regulating the thickness of the chamber of these mounts unless such supports are sealed in place, for they are very liable to get loose and damage delicate specimens if the slides are not kept constantly in a horizontal position.

The advantage of the foregoing procedure is that it provides ample contact of the cementing medium with both cover and slide and affords ample support for the cover against such pressure as it may be necessary to employ for occasional cleaning of the upper surface of the cover. Further, it provides for the exclusion of specimens from beneath that part of the cover glass which may be overlapped by the sealing ring. And the sealing ring may be kept entirely below the level of the upper side of the cover in case it is desired to employ close-working objectives for the marginal regions of the mount.

THE OSTERHOUT MOUNTING METHOD ADAPTED TO VOLVOCACEAE

A rapid method of mounting in aqueous media which was devised by Osterhout[3] is rendered more suitable for the larger *Volvocaceae* by the use of glass rodlets for cover-glass supports. It has been employed successfully for mounting stained specimens in nearly concentrated glycerin. I will describe the method as modified for my special purpose.

For each mount a larger cover glass, 18 mm square, and a smaller one, 11 mm square, are used. A pair of covers 22 and 15 mm square would give the same margin. It is advantageous to provide a special slide for the preliminary manipulations. This may consist of a slide with a small hollow-ground depression, to which are affixed glass or paper guides for holding the larger cover glass in position concentrically over a ruled square of the size of the smaller cover, the guides and ruled square being so placed that the hollow in the slide admits the tip of a forceps point under the margin of the larger cover glass. This ar-

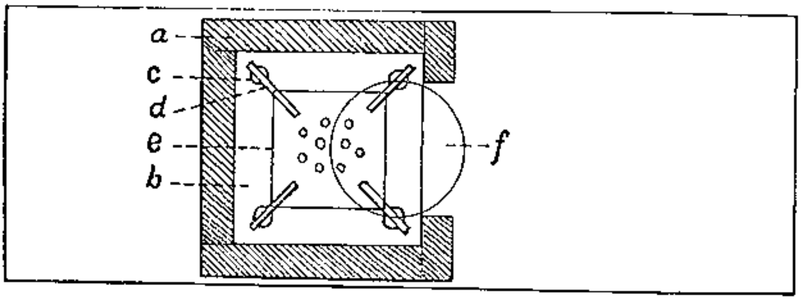

FIG. 1. Special slide with preparation ready for transfer to permanent slide. Glass or paper guides cemented in place, *a*; larger cover, *b*; balsam droplets, *c*; glass rodlets, *d*; smaller cover placed over the ruled square on the slide, *e*; depression in slide for forceps, *f*; material, the nine round bodies. Somewhat enlarged.

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[3] Osterhout, W. J. V., Contributions to cytological technique, *Univ. California Publ. Bot.* 2 (1904) 73-90.

rangement is shown in fig. 1. The larger cover is placed on this holder slide and a small drop of Canada balsam is placed on it near each corner. A glass rodlet of the required size is placed on each droplet so as to project into the area of the smaller cover, and pressed into contact with the cover. The balsam is allowed to thicken or harden. Specimens in approximately the proper quantity of glycerin are placed on the center of the larger cover glass and covered with the smaller cover. Excess of glycerin is removed by use of a capillary pipette or a piece of slightly moistened filter paper, with care not to moisten the margin of the larger cover or the upper surface of the smaller cover. A deficiency of glycerin is supplied from a capillary pipette. The smaller cover should rest firmly on the glass rodlets. The covers are then picked up with a pair of forceps, inverted, and placed, smaller cover lowermost, on a plain slide on which there has been placed, just previously, a drop of very thin balsam dissolved in xylene. As much balsam is added and allowed to run under the larger cover as is necessary to fill the marginal space. The arrangement is then as shown in fig. 2.

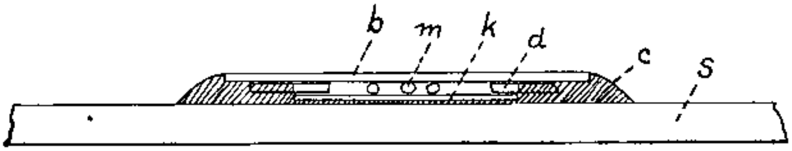

FIG. 2. Sectional view of permanent mount. Slide, *s*; larger cover, *b*; smaller cover, *k*; glass rodlets, *d*; balsam, *c*; material, *m*. About 2½ times natural size.

Osterhout cautions that—

> The balsam should be quite fluid so that the weight of the preparation will force it out from beneath the lower cover glass, since it will not do to press down on it for this purpose on account of the danger of forcing the water out from between the covers. Neither will it do to heat to any great extent, since this may cause bubbles. The preparation is now set aside to dry and treated like any balsam preparation.

A PLANKTON NET FOR LARGER ORGANISMS

After using several unsatisfactory means of collecting *Volvocaceae* I devised a plankton net which combines a number of advantages. The receptacle of this net is a sedimentation tube of 15 cc capacity with the bottom cut off and stopped with a cork. The bottom of the tube is removed by filing a nick near the closed end of the tube and pressing the tube firmly down on the end of a stick which fits inside the bottom. The cut end of the tube is then softened by heating in a flame and flared, by rotation on the conical tip of an arc lamp carbon, for the reception of the cork.

The net itself, of batiste or pearline lawn of suitable fineness, is conical in form, with the lower end open and just large enough to hold the upper end of the glass receptacle in the last centimeter of its length. The upper circumference of the net is sewed to a muslin band about 8 cm wide. The ends of this band overlap, but are united only by the lower and upper edges, leaving a placket gap for changing the glass receptacle when breakage occurs after the net is completed. The upper edge of the muslin band is hemmed to a metal ring, either plain or mounted with solder on the smaller end of a tapering ferrule. The plain rings are provided with strings for attachment to a pole. The mouth of the net is closed with a piece of bobbinet sewed to the muslin band near the ring for the purpose of excluding large objects. With this net it is easy to strain the organisms of certain dimensions from large volumes of water and wash them down into the receptacle where they may be inspected with a pocket lens.

In place of specially prepared sedimentation tubes, homeopathic vials have been used by cutting off the bottoms and smoothing and flaring the cut ends to fit the net. Nets with small rings or rectangular frames have been made to fit in metal pocket boxes such as those in which some brands of candy and tobacco are sold. The nets require to be dried before being stowed in these boxes.

Experience has shown that, in the tropics at least, the delicate fabrics, such as batiste, are liable to injury by gnawing insects unless well protected. One new net stood for several weeks against a wall and when used for the first time was found to have been eaten in several places. After repair with patches fixed in place with a mixture of beeswax and resin, the net was used, dried, and placed in a desk drawer. When required for use again it was found to have a fresh lot of insect holes. The nets in metal boxes are constantly ready for use.

WASHING DEVICES FOR SMALL OBJECTS

For washing chrom-acetic fixing solutions from quantities of *Volvocaceae*, amounting to several cubic centimeters in some cases, by a flow of distilled water, which neither compacts the mass of organisms nor washes any of them away, I have used several devices. The more satisfactory of these will now be described.

A simpler form consists of a calcium chloride U tube with two side tubes, fitted with a cork or rubber diaphragm holding a filter-paper floor, and a bent glass tube connected by a short rubber tube with one of the side tubes, as shown in fig. 3. A perforated cork fitted over the same side tube serves as means of hanging the apparatus on a rack. Water is supplied from an aspirator bottle on a shelf and controlled by a screw compressor clamp on a rubber supply tube having a glass nozzle. The U tube has an inside diameter of about 18 mm and a capacity below the side tubes of about 58 cc, and in one arm between the side tube and the filter floor holds about 15 cc. The diaphragm is a piece of cork or rubber stopper about 7 to 10 mm high with the smaller end slightly smaller and the larger end slightly larger than the bore of the U tube, perforated with a hole about one-third the diameter of the stopper. A piece of dry filter paper is placed over one mouth of the U tube and pressed into the tube with the larger side of the diaphragm, the margin of the paper being crimped and bunched. The diaphragm and paper are then withdrawn and the paper trimmed to leave a suitable margin, after which the diaphragm with its paper cover is inserted into the mouth of the tube, smaller side first, and pressed down almost to the bend of the U tube with the blunt end of a cork borer of larger diameter than the perforation of the diaphragm. The bent tube has its longer arm about equal in length to the distance from the mouth of the U tube to the side tube, is connected with the side tube of the open arm of the U tube, the inlet arm, and serves as a

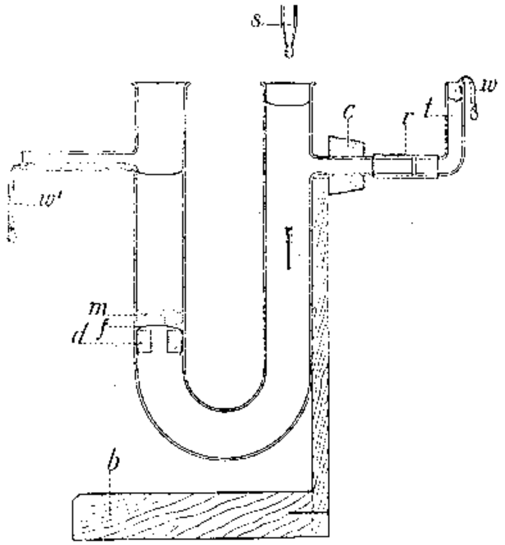

FIG. 3. Smaller washing apparatus made from a calcium chlorid tube. Diaphragm of cork or rubber, *d*; filter paper, *f*; material, *m*; filter paper wicks, *w*, and *w'*; glass tube, *t*; rubber connection, *r*; cork hanger, *c*; supply of water, *s*; base of stand, *b*. × ⅓.

means of regulating the maximum pressure of the water under the filter floor. The assembled apparatus in use is represented by fig. 3.

In use the bend of the U tube is first filled with distilled water to a level somewhat above the filter floor. Then, with the inlet mouth and side tube closed, the tube is inverted with the filter side lowermost, and shaken if necessary, to release all air bubbles from below the filter. It is returned to the upright position and hung on a suitable support. Next, the open side is filled with water up to the level of the outlet, and the liquid containing the specimens is quickly poured into the other side, the object being to prevent any fixing fluid from passing through the filter. In practice it is preferable to decant superfluous fixing fluid and dilute before pouring into the washing apparatus. After the specimens have been allowed to settle, a narrow wick of several layers of filter paper, pointed at the outer end, is inserted in the outlet tube to insure a steady outflow. The bent tube on the side tube of the inlet arm is provided with a similar wick and adjusted to provide for the maximum limit of pressure. Washing water is allowed to drop into the inlet mouth of the U tube.

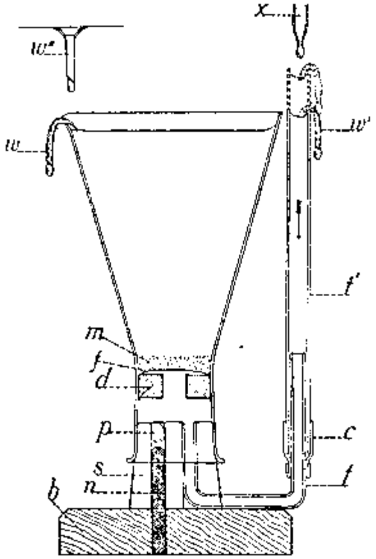

FIG. 4. Larger washing apparatus made from a flask. Diaphragm of cork or rubber, *d*; filter paper, *f*; material, *m*; plug, *p*; supporting rod, *n*; rubber stopper with two holes, *s*; glass tubes, *t* and *t'*; rubber connection, *c*; base, *b*; filter paper wicks, *w* and *w'*; supply of water, *x*; wick in front view of lip, *w*.'' × ⅓.

A form of this apparatus having a larger capacity is made by using an Erlenmeyer flask from which the bottom has been cut with a diamond, the edges smoothed by heating over a flame, and a spout, like that of a beaker, shaped in the larger end as shown in fig. 4. The flasks used have a nearly cylindrical neck about 4 cm long and 33 mm inside diameter, and it is preferable that this inside diameter be smallest near the union of the neck with the conical body of the flask. A ring diaphragm to fit tightly in the neck is cut from a cork or rubber stopper. The aperture in the diaphragm should be large enough to permit the exit of bubbles which may form between the diaphragm and the filter floor. The rubber diaphragms are about 10 mm thick and those of cork about 9. The mouth of the flask is provided with a two-hole rubber stopper, which fits tightly when about half of the stopper is within the neck. A channel is cut on the larger end from one hole to the margin. A glass tube of a size to fit snugly in the stopper hole is bent at right angles in two places so that one arm shall reach through the stopper from the channel to the smaller end of the stopper, and the other end shall extend upward in a vertical direction beyond the margin of the flask and a little higher than the filter floor. A straight piece of glass tubing, large enough to slip over the bent tube and long enough to reach from the bend of the small tube to the level of the flask spout, is provided on one end with a short piece of soft rubber tubing. If necessary, about 7 mm of this rubber tubing is turned back over itself to make it fit snugly over the bent tube. The inner end of the other hole in the stopper is plugged with a piece of tightly fitting glass rod or with beeswax-resin cement. A piece of wood to serve as a base for the apparatus is fitted with an upward projecting metal rod of a size to fit snugly in the stopper perforation and to reach almost up to the plug. The arrangement and use of this apparatus are shown in fig. 4.

To prepare the apparatus for use a piece of filter paper is placed over the mouth of the flask and pressed into the neck with the diaphragm, which is introduced larger side first. When the smaller side is flush with the mouth the paper is trimmed, and then the diaphragm is pressed, with a loosely fitting cork, so far into the neck as to be well beyond the reach of the stopper. Holding the flask mouth upward under a flowing stream of water, the neck is filled from filter floor to brim with care to exclude bubbles, the stopper is inserted with its bent tube in place, and the apparatus immediately inverted and placed in position on its base. Water is added to the level of the free arm of the bent tube. The larger tube with its rubber connection is slipped over the bent tube and filled with water, and immediately the specimens in fixing fluid, preferably previously diluted, are poured into the space above the filter floor. The specimens are allowed to settle, a filter paper wick is placed in the spout to insure steady outflow, and inflow of water into the tube is provided. The height of the inflow tube is adjusted to fix the maximum limit of pressure and rate of flow. Washing can be hastened by occasionally siphoning off the liquid from above the specimens, provided the filter paper will withstand the increased pressure.

Obviously these devices can be adjusted and used for washing with a flow of water in the opposite direction. For some classes of objects a large cylindrical vessel would serve the purpose as well as a conical one. The special advantage of the conical form is that it provides for the smaller, more slowly settling individuals among the specimens. Though prepared especially for washing *Volvox*, the larger, conical, washing apparatus was successfully used for washing 4 cc of pollen of *Cycas circinalis*.

METHODS OF ESTIMATING THE NUMBER OF CELLS IN SPHERICAL SURFACES

For estimating the number of cells present in *Volvox* coenobia various methods have been employed. Those used by the earlier workers have been critically discussed by Klein.[4]

Leeuwenhoek counted the cells around the periphery of the spheroid and calculated the total number present from the count.

Ehrenberg based his calculations on the same count, but, as Klein points out, his formula for the calculation was erroneous and gave numbers too large by more than half. Furthermore, his peripheral counts were, naturally enough, too large because of failure to limit the count to cells lying within an optical section no thicker than the average intercellular distance. The proper formula and coefficient for this method have been recently stated by Janet and are given below.

Cohn [5] counted the number of cells present in a measured area of the spheroidal surface (100 microns square) and calculated therefrom the total number, deriving the area of the spheroid from the radius. A special variety of this method was used by the present writer, and is stated in detail below.

Drude counted the cells in one-eighth of the spheroidal surface by means of a cross-hair ocular.

Klein described the method which he found expeditious for making numerous estimates. Using a camera lucida, he drew the periphery of the coenobium and within it a group of cells not extending so far from the center as to give any considerable error due to foreshortening of the intercellular distances by projection. In this group of cells, drawn as points, he selected 4 to 6 as nearly as possible in a straight line. He then determined how many times the length of this line was contained in the periphery.

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[4] Klein, L., Morphologische und biologische Studien ueber die Gattung Volvox. *Pringsheim's Jahrb. für wiss. Bot.* 20 (1889) 145–146.

[5] Cohn, F., Die Entwickelungsgeschichte der Gattung Volvox, *Festschrift* (1875) 15.

This measurement of the periphery was reduced to terms of average intercellular distance by multiplying it by the number of intercellular distances in the selected row. From this measurement of the periphery$=2\pi r$ he calculated r and then $4\pi r^2$. He thus obtained the area of the spheroidal surface in terms of the average area occupied by a single cell assuming the latter area to be equal to the square of the intercellular distance.

Janet[6] has recently applied to the above method the assumption, more in accord with fact, that each cell occupies a hexagonal area. Taking c the average intercellular distance, and d the mean diameter of the sphere, he gives the formula[7] for the total number, N, of cells as:

$$N = 3.627 \left(\frac{d}{e}\right)^2.$$

He also gives the formula for the calculation of the number of cells, N, from the number, n, of cells counted in the great circle which forms the visible contour of the median optical section. Based on the assumption that each cell occupies a hexagonal area of the spherical surface, the formula[8] is:

$$N = 0.367\ n^2.$$

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[6] Janet, C., Le Volvox. Ducourtieux et Gout, Limoges (1912), 28.

[7] This formula may be derived from those for the area of the surface of a sphere in which A is the area, r the radius, and d the diameter:

$$A = 4\pi r^2 = \pi d^2.$$

Since the area of a hexagon having a diameter of unity is equal to the sine of 60°, which is 0.86603, the number, N, of hexagons of unity diameter in the spherical surface is:

$$N = \frac{A}{0.86603} = \frac{\pi d^2}{0.86603} = \frac{\pi}{0.86603}\, d^2 = 3.627\ d^2.$$

The coefficient in this formula is, then, π divided by the sine of 60°; and d over e is the diameter of the sphere in terms of the average diameter of the area occupied by a single cell.

[8] This formula may be derived from that for obtaining the area of the surface of a sphere from the circumference of a great circle. A being that area, and c the circumference:

$$A = \pi \left(\frac{c}{\pi}\right)^2 = \pi \frac{c^2}{\pi^2} = \frac{c^2}{\pi} = \frac{1}{\pi}\, c^2.$$

Taking account of the fact that the area of a hexagon having a diameter of unity is 0.86603, the formula for the number, N, is:

$$N = \frac{A}{0.86603} = \frac{\frac{1}{\pi}\, c^2}{0.86603} = \frac{\frac{1}{\pi}}{0.86603}\, c^2 = 0.367\ c^2.$$

The coefficient in this formula is, then, the reciprocal of π divided by the sine of 60°; and n is the circumference of a great circle in terms of the average diameter of the area occupied by a single cell.

I have used a procedure which is an adaptation of that used by Cohn for estimating the number of cells in the coenobia. With a Zeiss acromatic objective D and a net-ruled ocular-micrometer adjusted so that each small square measured 18 microns on a side, an area of the object was selected which occupied 25 of the small squares, preferably 5 by 5. When shadows of daughter coenobia or other objects interfered with the use of a square area, groups of small squares in various arrangements were taken. When a good view of so large an area could not be obtained, a smaller area was used and the number counted multiplied by the factor required to give the number of cells in 25 small squares. Areas were taken as nearly central as possible, to keep down the error arising from projection of the spherical surface into the image plane. In cases where the intercellular distance decreased from anterior to posterior pole, either an equatorial area was used, or, in cases of polar presentations, a count was made around each pole and the average of the two counts taken. The count represented, then, the average number of cells in an area 90 by 90 microns square, equal to 8,100 square microns. The counts were made by inspection when convenient, otherwise by making a camera drawing of the boundaries of the area and the outlines of the included cells. Cells on the boundary were included when their larger parts lay within the boundary. The diameter of the coenobium was measured with an eyepiece micrometer, or with a camera lucida measuring scale prepared by making a camera lucida drawing of a stage micrometer. The latter is usually the more convenient way.

To use these data let d be the mean diameter of the coenobium in microns, a the area of the count in square microns, and n the number of cells counted. Then the formula for the number of cells, N, will be;

$$N = \frac{d^2\,n}{\frac{a}{\pi}}.$$

Using the same area for all counts, or reducing all counts to correspond to that area, the formula put in the form:

$$N = \frac{n}{\frac{a}{\pi}}\,d^2.$$

may be reduced, for the area 8,100 square microns, to:

$$N = \frac{n}{2578}\,d^2.$$

The slide rule was found most satisfactory for making the calculations. It is operated as follows: find *n* on scale A; bring *c*, the constant[9] 2578, on scale B opposite *n;* set the hair line of the runner at *d* on scale C; the number, *N*, is thereby marked by the hair line on scale A. The position of the decimal point in the number may be quickly found by reference to a previously prepared table of counts and diameters corresponding to cell numbers 1,000 and 10,000. Such a table may be easily made from slide rule readings.

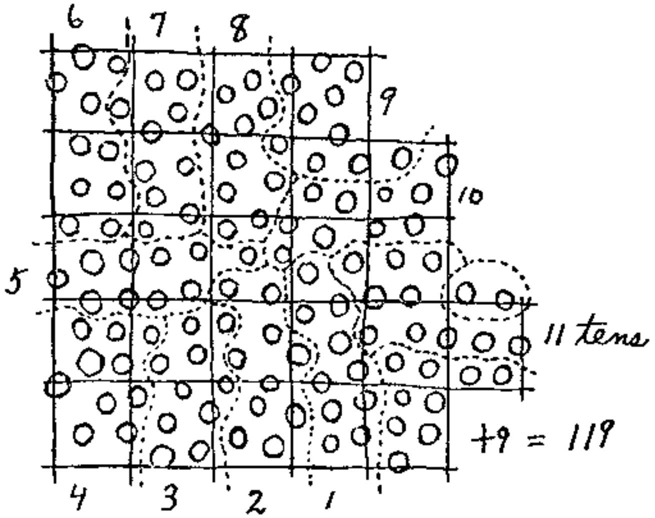

FIG. 5. A sketch of cells of a coenobium included within an area of 8,100 sq. μ indicated by the portion of the square-ruled ocular micrometer sketched at the same time. In practice the grouping lines, here drawn dotted, are drawn in red ink. The upper right square was not used because of some interfering object, the appended square at the right being substituted for it.

The foregoing may be illustrated by the following example: A spheroidal coenobium is found to have transverse and polar diameters of 610 and 635 μ respectively measured from center to center of cells at the ends of the diameters. We take 618 as an approximate mean diameter. Then we sketch, as in fig. 5, the selected area of the surface of the coenobium showing the cells and the micrometer lines. The cells counted are 119. We now place our constant mark on the slide rule under the 1.19 place on the scale A, bring the hair line of the runner over the 6.18 place on the scale C, and read under the hair line on scale A the number sought, which is about 17.7. A glance at our prepared table shows that for a count of 120 cells and diameters between 463 and 1,035 μ the range of cell numbers is from 10,000 to 50,000. Consequently our number must be 17,700.

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[9] For convenience in operating the slide rule I have marked this constant in two places on the slide rule which I use. To accomplish this in the best way, set the 8.1 mark on scale B under the π mark on scale A. Then make a mark on the B scale under the 1 mark of scale A. Then set the 81 mark on scale B under the π mark on scale A, and make another mark on scale B under the 1 mark on scale A. I cut these marks in the celluloid with a suitable sharp knife and fill them with red paint. This instrumental constant, dependent on the area selected for the counting of cells, is not to be confused with the constants c and c^1 which are marked on the C scale of some slide rules to indicate the square roots respectively, of four and forty times the reciprocal of π.

A modification of the above procedure was devised for the purpose of more closely approximating the number sought, and for simplifying the operation of the slide rule. The former purpose was attained by using a circular area instead of a square for the count, thereby eliminating the cells at the corners, these being more crowded in the microscope field because projected into the image plane from more sloping parts of the spherical surface. The area selected was, necessarily, smaller than the square, and for simplification of the slide-rule operation the area taken was 3141 square microns, for which area the constant, $c_{,} = a$ divided by $\pi = 1,000$. The circle was drawn by taking the radius 31.6 microns as measured on the drawing paper under the camera lucida from the image of a stage micrometer. For use with semitransparent drawing paper the circle was drawn with India ink on a white card, and for use with opaque paper the circle was carefuly cut out of a card. This was done to avoid errors which might arise from disadjustment of a pair of compasses. The circles were drawn on paper and within them the cells were sketched for counting. The counting was made easier in all cases by subdividing the area sketched, with red ink, into areolae containing ten cells each.

This method was first applied to checking over sketches and notes previously made by use of the square areas, and it served to disclose several clerical errors as well as errors which arose from projection.

An error which increases with decrease in the diameter of the coenobia is that which occurs if the diameter of the coenobia be measured from surface to surface of the spheroids. On this account, especially when working with small coenobia, the diameters were measured from center to center of cells on opposite sides of the coenobium, thus basing the reckoning on the spheroid in which the centers of the cells lie.

For cases in which very small areas suffice for the count a circle of 314 square microns was used, the radius being 10 microns, and the corresponding constant, k, is 100. This served for counts of cells of daughter coenobia within the parents.

For very large coenobia with widely separated cells the area taken for count was 31,416 square microns, the radius being 100 microns, and the constant, K, 10,000.

ILLUSTRATIONS

TEXT FIGURES

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